LUBRICATION ENGINEERING

RESEARCH APPLICATION EDUCATION MAINTENANCE

Welcome to Cleveland

JOURNAL OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS

Farval serves 1133 mill and crane bearings in Atlantic Steel's new bar and rod mill

FARVAL—
Studies in Centralized Lubrication
No. 205

KEYS TO ADEQUATE LUBRICATION—

Inset above shows Farval automatic pumping station No. 3, serving 240 points on 15 horizontal mills, edging mill, furnace switch and pullout, all designed and manufactured by Morgan Construction Company. Above you see *Farvalized* overhead crane and runout tables in the Atlantic Steel Co. mill room.

● Last word for modern machines and manufacturing practice, this Atlanta steel company also employs the most modern method of lubrication—Farval Centralized Lubrication. Twenty-four Farval systems keep mills and cranes running smoothly, serving a total of 1133 bearings.

You'll generally find Farval in evidence wherever steel is made or worked. Literally thousands of systems, automatic and manually operated, protect millions of bearings in the metals industries—some of them still efficiently on the job after 25 to 30 years of service.

Farval is the original Dualine system of centralized lubrication that delivers measured amounts of oil or grease under pressure to every bearing as often as desired. No bearing is ever missed.

Write for newly revised Bulletin 26-S, which tells the whole Farval story. The Farval Corporation, 3267 E. 80th St., Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.

LUBRICATION ENGINEERING

RESEARCH APPLICATION EDUCATION MAINTENANCE

Volume 14, No. 4

April, 1958

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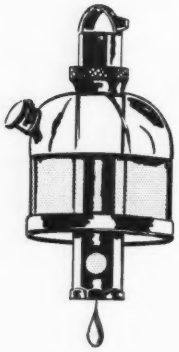
The Sight Glass



Highlights of Articles Scheduled for Coming Issues!

Effect of Capillary Length-to-Diameter Ratio on Grease Viscosity

Seven greases were tested in a capillary-tube viscosimeter to study the effect of capillary length-to-diameter ratio on their apparent viscosity. All greases were tested at 75°F, and three at 40°F. A change in apparent viscosity occurred in all greases for capillary length-to-diameter ratios to 250:1. Beyond this point there was little change in apparent viscosity with one exception: one grease exhibited a change to ratios of 1000:1. Reducing temperature increased the change in apparent viscosity for two given capillaries at a constant shear rate.

High Temperature Lubricant Studies

Basic information on the behavior of hydraulic fluids and lubricants is needed at temperatures above 400°F if successful operation of engines and hydraulic systems is to be achieved at high temperatures. It is necessary first to develop reliable test procedures and techniques covering the measurement of viscosity, lubricity, corrosion, and oxidation and thermal stability at temperatures of 500° F to 700° F. This paper describes the evaluation of several different chemical classes of fluids including silicones, silicates, hydrocarbons and mineral oils, diesters, and halogenated aromatic hydrocarbons. Property differences between the various types of fluids tested between the ranges of 500° to 700° F were found to be much narrower than exists between 200° to 350° F.

Considerations in Filter Selection

Design, tests, and quality control all have a bearing on the field performance of filter technology. Data obtained during operation of a filter system must be weighted as to significance of the requirement to optimum performance. Characteristics of certain filter media are compared. Laboratory techniques to assure predetermined filter qualifications are explained to briefly introduce filter technology to the lubrication engineer.

Plastics as Solid Lubricants and Bearings

Recent studies on the fundamental aspects of friction and wear of plastics are reviewed with particular reference to polytetrafluoroethylene. A review of wear data shows that the wear of polytetrafluoroethylene depends upon conditions of load and speed and the presence of fillers. Some applications of polytetrafluoroethylene and nylon bearing surfaces are described in relation to the physical characteristics of the materials.

THE BROOKS OIL CO.

Lube Engineering News

A REPORT ON THE DIFFICULT LUBRICATING PROBLEMS OF INDUSTRY

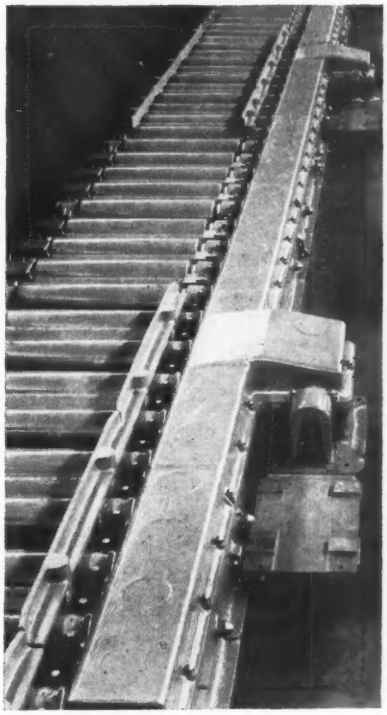
93% SAVING IN MILL TABLE LUBRICATION COSTS REPORTED BY LEADING STEEL PRODUCER

A leading steel producer recently went through a series of corrective measures to improve lubrication of mill tables. They went from circulating oil system to pressure grease system and finally to automatic spray system.

In the spray system, they used Brooks Klingfast and reported a saving of 93% in lubricant cost. They do not attribute the saving to the change in equipment, as various lubricants were tested. Klingfast offered the greatest reduction in lubricant cost for the application.

Records indicate a 35% decrease in man hours spent on this lubrication job, and 65% less maintenance delays, due to improved lubrication. Klingfast has proved itself against adverse conditions of mill scale, water and high temperatures. Savings in maintenance costs were coupled with increased production.

For full information, write for Engineering Letter 73LE.



NEW COLOR FILM AVAILABLE TO LUBE-ENGINEERING GROUPS

This new 30 minute 16 mm motion picture, in full color, with sound, shows a number of tough lubrication jobs. It pictures and describes the research, manufacturing and quality control methods that enable Brooks lubricants to "stand up" under severest service.

It's available to any supervisory or engineering group interested in lubrication problems. No charge, of course — we're glad to have you see it. Just call or write any of our offices and tell them you want to borrow "The Brooks Oil Story."

CIRCULATING OIL SYSTEMS REQUIRE LUBRICANTS THAT WITHSTAND SEVEREST CONDITIONS

Dust, dirt, water and metallic contamination present extremely difficult problems for circulating oil system lubricants — in steel mills, forging and press shops, cement plants and many other industries. Lubricating compounds must withstand constant contact with contaminants readily dissipate such foreign matter and maintain quality for continued service.

Brooks Leadolene and Klingfast are compounded to meet such severe conditions. These products have served industry for more than a quarter of a century and have broken many records. Companies in the United States and Canada have obtained 5, 10, 15 and 20 years of continued service from these lubricants. For complete facts, see your Brooks representative or write for Engineering Letter 86LE.

THE BROOKS OIL COMPANY

Established 1876

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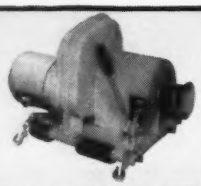


"OUR GUARANTEE IS PREDICATED ON THE USE OF LUBRIPLATE LUBRICANTS"

says
AIR CARGO EQUIPMENT CO.
at Glendale, Calif.

Our use of LUBRIPLATE Lubricants exclusively, followed the "torture testing" of our Bulldog Cargo Winch at an Air Force test center. The 196 pound winch, lubricated with LUBRIPLATE, was operated under a six ton load in environments of extreme heat, cold, salt, humidity, dust, altitude, explosive vapor and pressure. Now, our unconditional guarantee is valid only if the LUBRIPLATE Lubricants, factory sealed in our winches, are not replaced by other lubricants.

John J. Terlep, Sales Manager

REGARDLESS OF THE SIZE AND TYPE OF YOUR MACHINERY, LUBRIPLATE GREASE AND FLUID TYPE LUBRICANTS WILL IMPROVE ITS OPERATION AND REDUCE MAINTENANCE COSTS.

LUBRIPLATE is available in grease and fluid densities for every purpose . . . LUBRIPLATE H. D. S. MOTOR OIL meets today's exacting requirements for gasoline and diesel engines.

For nearest LUBRIPLATE distributor see Classified Telephone Directory. Send for free "LUBRIPLATE DATA BOOK" . . . a valuable treatise on lubrication. Write LUBRIPLATE DIVISION, Fiske Brothers Refining Co., Newark 5, N. J. or Toledo 5, Ohio.

LUBRICATION IN THE NEWS

Wage-Hour Law Not Applicable To Consultants

Employees of consulting engineering and architectural firms are not covered by the Federal Wage-Hour Law, according to a recent ruling of the U. S. Court of Appeals for the Fourth Circuit. The decision, dismissing a department of labor suit for an injunction against the Washington-Norfolk engineering-architectural firm of Lublin, McGaughy and Associates, may be appealed to the Supreme Court by the government.

A recent issue of the National Society of Professional Engineers' newsletter, *Engineering Employment Practices* said that the decision is the latest in a series of cases testing the basic question of whether the performance of professional consulting services constitutes the furnishing of "goods" for interstate commerce, or an engagement in commerce. In an earlier case, the Eighth Circuit Court held an engineering firm subject to the Wage-Hour Law. Several district courts have also ruled on the question, each time in favor of the consulting engineering firm.

According to the U. S. Court of Appeals' decision, plans, drawing, specifications and blueprints prepared by the firm are not "goods" within the meaning of the law; they are only a written permanent form of professional advice. Interstate travel and communication by employees of the consulting firm does not constitute an engagement in commerce, the Court said, because the essence of the activity is related to local work. The Court also rejected the government argument that the activities of the firm in question constituted an indispensable link in the chain which culminates in interstate commerce.

NSPE has urged Congress to amend the law to clarify the fact that it was not intended to, and does not, apply to the furnishing of professional consulting services.

Service Station For 2-Wheelers

So many Europeans are buying two-wheel motorcycles, motorscooters and motorbikes that French technicians have developed new service station equipment especially for them. To repair, grease and maintain the powered two-wheelers, the *S.A.T.A.M.* Company of La Courneuve, just outside Paris, is producing a mobile, all-inclusive unit which has, among other utilities, a low-powered compressor, two oil pressure pumps, a high-pressure grease pump, a catch basin for oil changes, and a tool shelf. *France Actuelle*, a report for Americans on modern France and the French Union, calls the steel-tubed unit "a miniature service station in itself." It can be added to the equipment of existing garages and service stations, form the basis of new service stations catering particularly to two-wheelers, or serve the need of large industrial enterprises and farms.

Hoar Wins NACE's Whitney Award

The 1957 National Association of Corrosion Engineers Rodney Whitney award was pre ented to T. P. Hoar, lecturer in metallurgy at England's Cambridge University. The Frank Newman Speller award was presented to Robert J. Kuhn, New Orleans Public Service corrosion engineer for more than 30 years. The awards were given out in San Francisco on March 19 at the NACE's annual banquet.

Machinery and Tool Imports To Highlight '58 Trade Fair

Latest developments in high-quality imported machinery and precision tools will be featured in a new special section of the 1958 United States World Trade Fair at the New York Coliseum from May 7 to 17.

The machinery and precision tool sections will be part of a newly-expanded group in the fair's product and services classifications. Along with machinery and precision tools in this area (8) will be: power equipment, electronic equipment, scientific instruments, building materials and supplies, plumbing, electrical equipment and motors and basic materials.

Last year's U. S. World Trade Fair consisted of 43 officially participating nations with a total of 3000 exhibitors displaying products and raw materials from 60 countries to 127,780 buyers. Buyers, representing every segment of the world's industry, came from every state in the union and from 77 foreign countries.

BARAGEL* PROVIDES 3 ESSENTIALS for the grease manufacturer

EFFICIENCY
EXCELLENCE

BARAGEL
Provides manufacturing **ECONOMY** resulting in lower grease cost.

BARAGEL
Provides improved **EFFICIENCY** giving more grease per pound of thickener.

BARAGEL
Provides greases of **EXCELLENCE** because of outstanding performance.

BAROID CHEMICALS, INC.
A SUBSIDIARY OF NATIONAL LEAD COMPANY
1809 SOUTH COAST LIFE BLDG. HOUSTON 2, TEXAS

**Trademark of National Lead Co.*

The compactness of downtown Cleveland, includes the proximity of the Terminal Tower, with the Municipal Stadium and the Public Auditorium.

ASLE Officials Greet Meeting Visitors

Your National Program Committee, starting some fourteen months ago, has provided for you an outstanding group of authors and technical papers, as one glance at the program will convince you. This year, much more so than ever before, the technical committees and the industry councils have had a direct part in the selection and review of the papers to be presented. More than ever before this year's program reflects the broad interests of the Society. As a result, there is much of great interest to every one of you. We hope you will attend as many of the sessions as possible, and that you will participate actively in the discussion periods provided. By so doing, you will not only enrich your knowledge and appreciation of the subject, but will arouse a spirit and enthusiasm that will greatly aid your Society and your own work as well.

McLEAN

In addition to the technical sessions, there will again be an educational course for those desiring it, sponsored by the Education Committee. These courses have, in the past, been well received and are designed to cover various fundamentals in the field of lubrication.

Following last year's example, the banquet will feature awards of recognition for outstanding contributions to the field of lubrication, entertainment, and dancing which proved so popular at the '57 Meeting. *There will be no formal banquet speeches.*

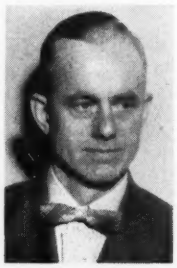
On behalf of your Society, we welcome you to the 13th Annual Meeting and Exhibits of the American Society of Lubrication Engineers. It is your meeting. Get out of it all that it is designed to give you.

Cleveland, Ohio, the hub of the Ohio Valley industrial area welcomes all of our guests in the tallest building unit in the heart of Public Square. A full program for the ladies and a busy social and educational schedule for the Engineers in planned sessions, heralds this National Convention.

This, our second national gathering in Cleveland pledges to fulfill all your expectations. Cordial, prompt and friendly cooperation will be given to all, so stay from start to finish and absorb all the wealth of knowledge, pleasure and experiences we in Cleveland have arranged. Tours, luncheons, TV programs, banquets, entertainment and friendly hosts await your arrival. (W. J. Hurley, Chairman, Host Section)

The National Program Committee welcomes you to the 13th Annual

McCULLOCH



HURLEY

Welcome to Cleveland -

Cleveland is a big, busy city — Ohio's first and the nation's seventh. This is a city of more than a million people, the capital of a great trade empire, and an industrial giant ranking with the greatest in the world.

Cleveland offers all the attractions of a great metropolis befitting its size and prestige. The cultural and educational institutions, the parks, and the entertainment facilities of Cleveland are among the finest in the world. The beautiful shores of Lake Erie, both east and west of the city, offer a great variety of attractions. And the entire area surrounding the great city is one of beauty and interest.

All major hotels, the shopping district, transportation points, amusements, Lake Erie, and the Public Auditorium are all within a few minutes' walking distance. Any point in the city is easily accessible from the downtown area.

At the hub of the city's business activities is the Public Square, a modern business and transportation center valued at more than $20,000,000.

Towering over the square is Cleveland's familiar landmark, the 52-story Terminal Tower, with an observation room on the 42nd floor that affords a splendid view of the city.

Meeting and Exhibit of the American Society of Lubrication Engineers.

Our efforts have been directed toward making this a "Lucky 13" for you by providing the biggest, the best, and the most diversified program in ASLE history. Each of you must measure our success in this regard, but whether you plan your plant lubrication program, develop specialized products, actually apply lubricants or reap the rewards of continuous machine performance, you will find several phases of each day's program of special interest to you. Take advantage of this by attending the technical sessions and participating in the floor discussions. This is your program. (H. W. McCulloch, Jr., Chairman, National Program Committee.)

EARLE A. RYDER

Earle Ryder Receives ASLE National Award

The awards committee has announced that the recipient of the 1958 ASLE National Award will be Earle A. Ryder, internationally known aircraft industry consultant, for his contributions to lubricant evaluation.

The national award, highest honor bestowed upon an individual by the Society, signifies honorary life membership in the ASLE. It is awarded in recognition of an outstanding contribution to the field of lubrication engineering. Award recipients need not be members of ASLE. Past recipients include:

Walter D. Hodson—1948
Charles F. Kettering—1949
Lawrence G. Benton—1950
Meyo D. Hersey—1951
John W. Stack—1952
John J. Simon—1953
Allan F. Brewer—1954
F. P. Bowden—1955
Oscar L. Maag—1956
Dudley D. Fuller—1957

The Society offers other awards in recognition of outstanding papers presented before the Society or published in *Lubrication Engineering*. The *Captain Alfred E. Hunt, Memorial Award* is made to an ASLE member for the best paper presented

To recognize and stimulate the interest of young engineers in the science of lubrication engineering and ASLE activities, an award of $25 and a plaque is awarded to a member 30 years of age or less for the best paper presented before the Society or published in *Lubrication Engineering*. The award, named the Walter D. Hodson Award, is in memory of one of the Society's founders.

The Society's newest award, offered in recognition of the best paper dealing with those phases of lubrication engineering of interest to plant personnel responsible for lubrication of industrial lubrication, is the *Wilbur Deutsch Memorial Award*. This award is presented annually in memory of Wilbur Deutsch, ASLE president 1956-57, who was stricken by leukemia a week after taking office. A

DEL RAY

RHYTHMETTES

RICO

Rhythmettes, Del Ray, and Music by Rico To Entertain Banquet Guests

The Cleveland Host Section has assembled some excellent entertainment for the annual meeting banqet, Wednesday, April 23, 1958. Featured on the program are the *Rhythmettes*, direct from the opening of the new Capri Hotel. Havana, Cuba. Latest song stylings, including their record hits and some of the tunes which have pleased audiences in cafes across the country will be offered. Outstanding prestidigitational (that's magic!) effects to keep the banquet entertaining will be provided by the talents of *Del Ray*. For those light of foot, *Rico* and his orchestra will provide dance music. Well known throughout the Cleveland area, *Music by Rico* brings a unique styling through unusual arrangements for orchestra.

Banquet tickets available at the registration desks and guests are invited.

NEW! A lube oil additive for modern, high-power gasoline engines

Specifically designed for "stop and start" driving!

As auto makers continually develop more critical, more powerful engines—as "stop and start" motoring becomes more a part of everyday driving—good performance from lubricating oils becomes an increasing problem. Foreseeing this trend, Oronite, with five years of research, thousands of laboratory tests, millions of miles of road operation, is proud to announce the FIRST lube oil additive designed to meet the more precise requirements of modern-day gasoline engines—and the engines of the future.

Revolutionary new Oronite "60" Series additives are actually a new approach to compounding motor oils. The modern car engine is engineered to pour in fuel at high horsepower levels. Fuel is not completely burned at low "stop and go" driving temperatures causing gums and sludge to form. Present day compounded motor oils do not disperse these harmful foreign deposits as effectively as is now possible. New Oronite "60" Series additives incorporate an ashless detergent component that virtually eliminates oil ring clogging, reduces cylinder and ring wear to a very minimum. The result is a marked improvement in engine life and service under all types of operating conditions.

Oronite "60" Series additives can provide you an important "first" in marketing a superior compounded motor oil for the present and future. They can be used in compounding single, dual or multi-graded oils of outstanding performance.

Get the complete story on Oronite "60" Series additives. Contact the Oronite office nearest you or write for technical bulletin giving complete proof of "60" Series' capabilities.

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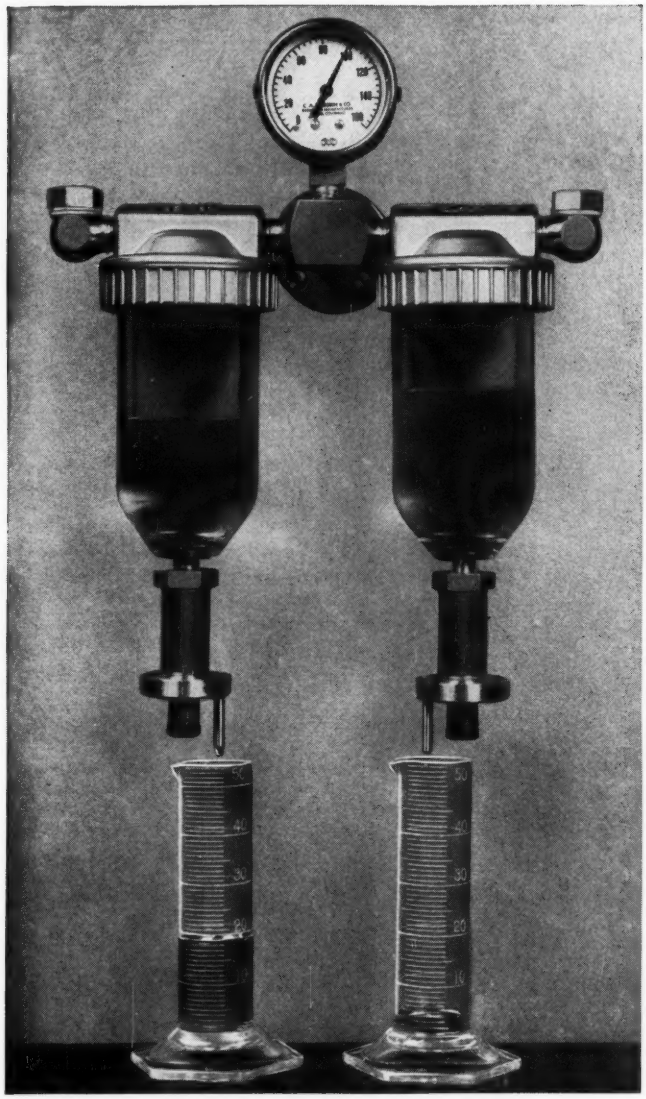

ANTILEAK DEMONSTRATION

Suntac oil in one chamber, your present hydraulic oil of the same viscosity in the other. Both oils are forced out through sintered bronze bearings. In this photograph, pressure of 100 psi caused a straight mineral oil to leak out four times faster than Suntac.

SUNTAC CUTS HYDRAULIC OIL LOSS AS MUCH AS 75%

See this demonstration in your plant

Take about five minutes at your own desk to learn how Suntac® oils stay put in hydraulic systems . . . reduce oil loss through loose joints and worn fittings.

Match Suntac against the hydraulic oil you're now using—see how the exceptional non-gummy antileak characteristics of Suntac can reduce your oil losses as much as 75%. *Some users have even reported savings of 90%.*

Call Your Sun Representative

Have him arrange with a Sun Lubrication Engineer to give you and your staff a private demonstration. For further information on the uses of Suntac in hydraulic systems and in general lubrication, write to SUN OIL COMPANY, Philadelphia 3, Pa., Dept. LE-4.

SUNOCO

INDUSTRIAL PRODUCTS DEPARTMENT

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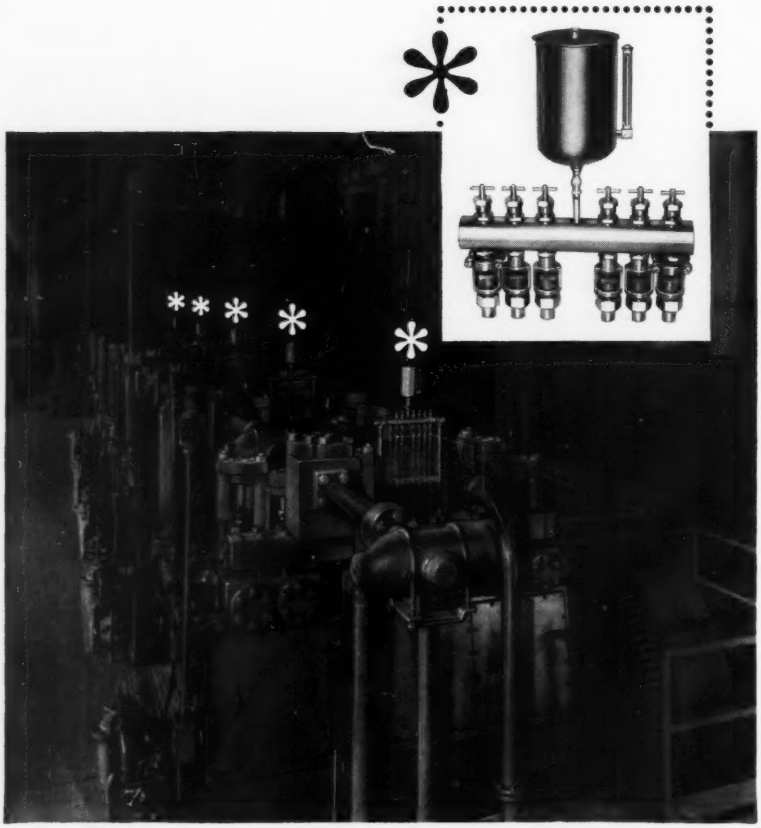


NUGENT
MULTIPLE GRAVITY OILERS Provide Controlled Lubrication for hard-to-reach bearings

The five Worthington Power Pumps shown above supply hydraulic power for a central hydraulic accumulator system in a large aluminum mill.

Each pump is equipped with a Nugent Multiple Gravity Oiler. The feeds may be individually controlled to deliver lubrication in predetermined quantities to otherwise inaccessible bearings.

Nugent Multiple Gravity Oilers are available with 2 to 23 feeds. Pressure Sight Flow Lubricators are also part of a full line of Nugent lubricating specialties. Before you decide on any filtration or lubrication equipment . . . see what Nugent has to offer.

ESTABLISHED 1897

REPRESENTATIVES IN PRINCIPAL CITIES

WM. W. NUGENT & CO., INC.
3466 CLEVELAND STREET, SKOKIE, ILLINOIS

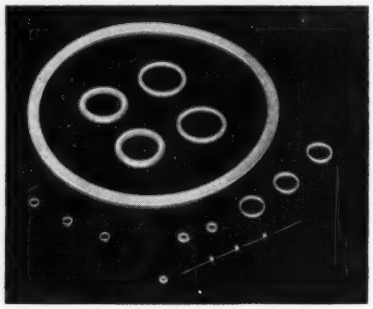
OIL FILTERS • STRAINERS • TELESCOPIC OILERS
OILING AND FILTERING SYSTEMS • OILING DEVICES
SIGHT FEED VALVES • FLOW INDICATORS

SOLUBLE OIL BACTERICIDE

An improvement which makes tetrachlorophenol technical more free flowing has been developed by John C. Vander Weele of the Dow Chemical Company. Tetrachlorophenol technical Dowicide 6, is used as a fungicide by the paint industry and as a bactericide by soluble oil manufacturers. When applied at the proper concentration, tetrachlorophenol renders oil paint films mold resistant and controls bacteria in soluble oils. A complex crystalline structure keeps this phenolic chemical more free flowing much longer than the product formerly made. The patent granted Vander Weele in Dow's name covers application of 70 to 82½ per cent by weight of crystalline 2, 3, 4, 6 tetrachlorophenol and correspondingly between 30 and 17½ per cent of pentachlorophenol. About 0.1 per cent of the product is incorporated into soluble oil.

TEFLON TUBING CONNECTORS

Tubing connectors made from Teflon which are said to be superior in laboratory, glassware and equipment applications in-

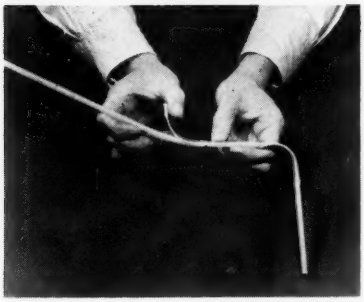


volving high temperatures, strong solvents or corrosive materials have recently been developed. The connectors have a service temperature range from 500 degrees F down to the temperature of liquid oxygen, are not attacked by any acids, bases or commercial solvents and will not contaminate any fluid stream. The PF connectors permit misalignment of the tubing or apparatus without restricting the flow, are reusable and easy to clean. Pre-cut to proper lengths in sizes for all standard glass tubing, the connectors reportedly replace rubber, "Tygon" or expensive ground glass joints. Connections for a drain line can be made to the tubing or apparatus by a simple tight fit; for vacuum or pressure application by cementing or wiring, or by use of a hose clamp. For additional information write Pennsylvania Fluorocarbon Co., 115 N. 38th St., Philadelphia 4, Pa.

New Products

BENDING CLIPS AVAILABLE FOR PLASTIC TUBING

A clip for holding a bend in plastic tubing is now available from The Polymer Corporation. Developed for Polymer's new



Nylaflow polyamide tubing, the new attachment accessory is designed to hold a permanent 90° bend in ¼" OD tubing. The bend radius is 1 in. Used to save installation time in such applications as instrumentation, hydraulic, lubrication, air or other fluid lines where quick bends are indicated, the clip is manually attached by snap-on procedure, and is easily removed and placed at another selected location on the tubing. Further information is available from The Polymer Corporation of Pennsylvania, Reading, Pennsylvania.

PANCAKE MOTOR DEVELOPED

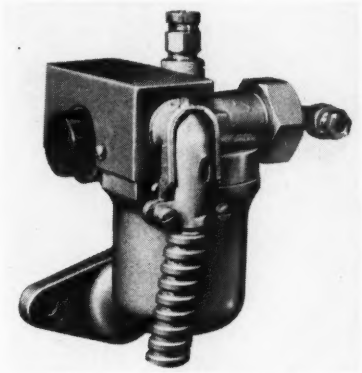
A new pancake motor that is said to reduce motor length up to 60% over standard motors of the same rating, is designed for use on machine tools, roof-ventilating fans and many other space-cramped applications. The product is a flange type motor of conventional radial air-gap design. It achieves its short length, without any reduction in motor performance, through formed end coils and a one piece housing-bearing bracket. For normal operating conditions it is built in an open drip-proof enclosure. Where dirt, filings, corrosive chemicals, coolants or other contaminants are present, the motor is furnished in an enclosed construction. The motor is available in ratings from 1 to 15 HP at 1800, 1200 and 900 RPM. Additional features include: vertical or horizontal mounting, cast iron housing-bearing bracket, modern appearance, factory lubricated bearings, and quiet operation. For complete information, request bulletin 2100 on the pancake motor and/or 2150 on the open drip-proof motor, from the Louis Allis Co., Dept. P, 427 E. Stewart St., Milwaukee 1, Wisconsin.

SPEED REDUCER LINE

The Ohio Gear Company has announced the introduction of three new fin-cooled speed reducers. Designated the series "20" line, they consist of single worm gear reduction, right angle, drive units. Models include both horizontal and vertical output shafts. Completely redesigned, with new, heavier housings, heavy duty anti-friction bearings and precision worms and gears, the reducers are built to provide long service life, even under rugged operating conditions. The new models are designed for use with motors up to 1.5 horsepower. Output horsepower and torque vary with speed and input horsepower. There are six standard ratios for each of the three basic models, ranging from 9:1 to 58:1. Approximate weight of each unit is 22 lbs. and lubricating oil capacity is one pint. Typical overall dimensions of the new reducers are: base, 7" x 4-¾"; height, 6⅝". For complete information on this new speed reducer line, write Ohio Gear Company, 1400 East 179th Street, Cleveland 10, Ohio.

NEW "OIL MONITOR" REDUCES DOWN-TIME

A new protective device, which prevents re-cycling when compressor crankcase oil level falls below a safe limit, is now stand-



ard equipment on the 1958 Champion line of stationary and portable air compressors. Called the "oil monitor," the new device employs a micro switch which makes it impossible for the compressor to start a new cycle unless sufficient oil is present to do a thorough lubricating job. Recycling can only be accomplished by the operator manually pushing a button on the side of the monitor. But even then the compressor will cut off automatically at the next cycle, and so on, until oil is added to bring the crankcase level up to standard. The major cause of down-time on electrically driven compressors is oil shortage, which causes piston seizing. Now Champion compressors, fitted with the new "oil monitor," are claimed to effectively eliminate this last cause of breakdown. All compressors in the Champion line, from 1-½ to 10 hp, are fitted with the new unit. They are produced at the Champion Pneumatic Machinery Company plant at Princeton, Ill.

SNAP-IN FLOWMETER

Fischer & Porter's new 2700 Series variable-area flowmeters feature packing-less, snap-in metering tubes. By using O-rings to seal the tube ends to the metal fittings — nuts, bolts, stuffing boxes, packing glands and all adjustments have reportedly been eliminated. Piping strains cannot be transmitted to the glass metering tube since the tube "floats" in the O-rings. Side frames and front and rear covers are also of snap-in construction. The new design permits coverage of flow ranges from a fraction of a cc/min to 40 gal/min with only three meter sizes. As eight sizes were required formerly, inventory costs can now be reduced 50 to 75%. Metering tubes can be "snapped-in" without use of tools and without disconnecting or disassembling meter. Cleaning and range changing are reduced to simple, quick routines. All dimensions conform to standards of ISA Recommended Practices (P.R. 16.1 — tentative). For further information write Fischer & Porter Co., 577 Jacksonville Road, Hatboro, Pa.

FIRELESS STEAM CLEANER

A two-page bulletin describing the Kelite fireless steam cleaner, is being offered by Kelite Corporation. The bulletin describes how the Kelite fireless, which is less expensive than comparable direct-fired steam cleaners, uses live steam from an existing steam supply, thus providing the efficient cleaning power of high-volume steam cleaners. The bulletin points out that maintenance of the machine is a simple matter since fire, soot, heat exchanger, scale, and special controls are eliminated. It adds that the Kelite Fireless is especially useful in hazardous locations where an open flame is not permitted, but where a steam supply exists. In addition to illustrations of the Kelite fireless steam cleaner and its steam gun features, the bulletin carries a table of specifications and a list of optional equipment. Interested readers should ask for Bulletin P-7578 from Kelite Corp., 81 Industrial Rd., Berkeley Heights, N. J.

LATHE CUT RINGS OFFERED

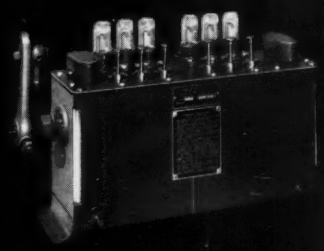
With perfection of new method production equipment, Parker Rubber Division announces the offering of lathe cut synthetic rubber rectangular cross section rings for sealing applications. These are available in all the various compounds from which Parker O-rings are molded. The new Parker process economically produces "flat" rings to dimensional accuracy within closer tolerances than ordinary lathe cutting, making the rings suitable for many gasket applications. Further information is available from T. J. McCuistion, Parker Rubber Division, Parker-Hannifin Corporation, 17325 Euclid Avenue, Cleveland 12, Ohio.

MANZEL

accurate,
controlled,

Get the automatic, timed lubrication you need to protect valuable machinery, eliminate downtime, cut maintenance costs. Wide range of Manzel Lubricators and controls, in single and multi-feed units, will solve any lubrication problem. A Manzel field engineer will help select the model you need.

WRITE FOR COMPLETE CATALOG giving specifications and performance requirements to meet any of your lubricator needs.



Manzel

273 Babcock Street • Buffalo 10, New York

HOUDAILLE *Specialists in metering pumps and lubricators since 1898*

PERSONALS

Vincent E. Bowes has been promoted to midwestern sales manager of Kelite Corp., manufacturer of industrial chemicals and steam cleaning equipment. Working out of headquarters in Chicago, Bowes will be in charge of sales in Illinois, Indiana, Iowa, northern Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, Wisconsin, and North and South Dakota. Also at Kelite, George S. Johnson has been appointed district sales manager to head sales in the Indianapolis, Indiana district while Robert G. Hazel will be in charge of sales in Kelite's Beaumont, Texas district.

Luther E. Beiswanger has been named director of industrial engineering for the Organic Chemicals Division of American Cyanamid Co.

The De Laval Separator Co. of Chicago has opened a new district office in Minneapolis with Don E. Hutson in charge of operation.

STROTHER

SHEFFIELD

James R. Strother has joined Flexonics Corp., Maywood, Ill., as assistant sales manager for industrial hose products. In his new position, Strother will manage the company's national sales of metal, synthetic rubber and plastic hose products.

From Pure Oil Co. comes news of two appointments to newly created positions. Robert J. Askevold and Dr. Donald C. Bond will serve as assistant research directors with Askevold in charge of marketing and refining research activities while Dr. Bond heads production and transportation research.

Clifford Oman has been named assistant plant manager for National Petro-Chemicals Corp. at Tuscola, Ill.

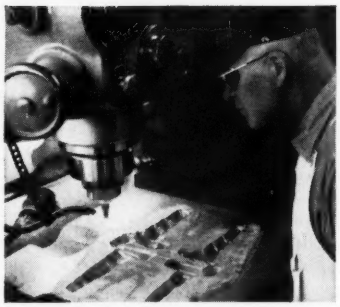
Parker S. Dunn, vice president, manufacturing, of American Potash & Chemical Corp., has been elected to the company's board of directors.

William Sheffield has been appointed treasurer of the Garlock Packing Co. of Palmyra, N. Y.

James R. Greaves has been appointed sales representative of the Joseph Dixon Crucible Co. of Jersey City, N. J. He will handle the company's full line of graphite lubricants, paint and enamels, crucibles and refractory products from his headquarters in Los Angeles.

Interstate Drop Forge Company—

20 Years a Cities Service Customer and Still Forging Ahead!



The modern way to cut a die is typified by die sinking machine, one of many at Interstate Drop Forge Company. All die sinking machines are lubricated by Cities Service lubricants.

With production running at roughly 1000 tons per month, Interstate Drop Forge Company of Milwaukee is one of the largest forging concerns in the Wisconsin area and growing all the time.

An integral part of this growth story, Cities Service is proud to have filled Interstate's lubrication needs for the past 20 years.

Drop hammers . . . helve hammers . . . upsetters . . . forging rolls . . . shapers . . . automatic metal saws. These are but a few of the diversified machines lubricated by specially tailored Cities Service oils and greases.

Actually, in a plant of this type with so many differing pieces of machinery, it would be possible to have as many as 25 different lubricants. But, Interstate, with the aid of their Cities Service Lubrication Engineer has been able to standardize on twelve Cities Service lubricants.

Streamlining . . . standardizing . . . improving. These are some of the services a Cities Service Lubrication Engineer can render for your operation, too. Ask him to make a free lubrication survey of your plant. Call the nearest Cities Service office or write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

Visit Booths 11 & 12, ASLE Convention, Cleveland Hotel, April 22-24.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

View of the speakers' table for the recent ASLE/SAE Joint Automotive Lubrication Conference, sponsored by the Chicago Sections of the two societies. Guests included the national president of ASLE, section officers and outstanding lubrication engineers from the midwest states.

Joint Automotive Lube Confab Draws 160 to Tech Sessions

ASLE's Chicago Section reports the success of its March 11 cooperative section-sponsored lubrication conference with the Chicago Section, SAE. More than 160 engineers registered for the six papers and discussions sponsored by the two groups. The following abstracts treat the six papers presented.

"Octanes From Motor Oils" by M. L. Kalinowski, L. D. Lacroix, and R. A. Nejdl, Standard Oil Company (Indiana), Whiting, Indiana.

Motor oils contribute to combustion-chamber deposits and therefore to octane-requirement increase (ORI) and surface ignition. Laboratory investigation of the separate components of motor oils shows that base oils add greatest contribution to octane requirement increase, that viscosity index improvers add less, and that detergents and inhibitors add the least. Surface ignition is reduced by phosphorus, barium, calcium and zinc—elements commonly found in motor oil additives.

A good choice of base stock viscosity index improver and detergent for an SAE Penn 10W-30 Oil gives an octane requirement increase 6 octane number lower than a poorer choice. Choosing phosphorus-containing detergents and inhibitors reduces octanes needed to suppress surface ignition as much as 14 units. Formulation of motor oils can do much to save costly octane numbers.

"Low Temperature Behavior in Motor Oils." T. W. Selby, General Motors Research Staff, Warren, Michigan.

The behavior of motor oils at low temperatures is important to the performance of the motor. Low temperature cranking speeds have been shown to be dependent upon viscosity. In a previous paper, the author has shown that viscosity characteristics of motor oils at these temperatures may be unusual, especially when they contain viscosity index improvers.

This paper analyzed the results of 250 cranking tests conducted at temperatures of from $+3°$ to $-35°$F. These results were compared using the viscosities as determined in the moderate shear viscometer and extrapolated and calculated by the ASTM chart in a recently published analytical technique.

"Lubrication of Outboard Motors," W. C. Conover, Outboard Marine Corporation, Waukegan, Illinois.

Between the years 1951 and 1957, annual sales of outboard motors involving a two-cycle motor jumped over 100%. Horsepower increased from 8.9 to 16.3 average per unit. Although the outboard motor is water-cooled, additional two-cycle engines in this category are air-cooled. Lubrication of the engine is made by scavenging the gasoline with oil contained in the gasoline to provide lubrication. In film strength, the gasoline-oil mixture was no different than that of the gasoline without the oil. If the lubricant has been added to gasoline and lacks sufficient film strength at the temperature of two bearing surfaces in contact, seizure of metal parts results. The paradox of this problem is that temperature is necessary for distillation of gasoline, but an increase in temperature reduces the film strength of the remaining oil as lubricant.

The author called for a cooperative program to solve the above problem in order to provide closer cooperation between the engine builders and the petroleum industry.

"An Engineer Looks at Industrial Lubrication" by B. M. Dunham, Sun Oil Company, Philadelphia, Pennsylvania.

The roll of the lubrication engineer and his importance as a member of the production engineering staff in automotive plants has increased with the addition of automated equipment involving transfer machinery coupled with production machinery. The author incorporates listings of various types of machine tools, presses and associated equipment and shows the evolution of these into present-day automation production units. Tables are advocated for simplified lubricant recommendations in application of lubricating oil of differing viscosities for such equipment.

"Determining Wear in Automotive Engines" R. L. Pontious, Sinclair Research Laboratories, Harvey, Illinois.

Recent changes in design performance requirements associated with the trend of high power outputs have accentuated wear problems in modern engines and stressed the need for development of suitable lubricants to prolong the useful life of these engines. Better wear tests for predicting lubricant performance are required.

The paper describes several laboratory tests used in determining wear in single-cycle and multi-cycle engines and their applicability to specific wear problems affecting lubricant development. Piston rings, piston pin and valve wear under various operational conditions are discussed.

"Lubrication of Railway Journal Roller Bearings" by P. C. Patterson, The Timken Roller Bearing Company, Canton, Ohio.

The author reviews experiences with lubrication of railway journal roller bearings from early installation through the present time. Requirements and desirable characteristics of lubricants are discussed, and the thinking applied to the various types of lubricants used in lubricating rolling stock which led to the current work of the American Association of Railroads is covered. Work of standardization in bearing assembly sizes for each AAR axle size is detailed, as are the manufacturer's method of pre-lubricating the roller bearing assembly and supplying it to the customer as a pre-assembled, pre-adjusted unit ready for installation.

Section News

Baltimore — February meeting featured Texas Company's R. J. Ronan's discussion of "Rust Preventives from Petroleum." . . . **Boston** — "Metal Working" was detailed by E. J. Krabacher, Cincinnati Milling Machine Co., at March meeting. Keeping ahead of the times, Boston Section sponsored a one-day symposium on "Lubrication for Tomorrow" on March 26, heard from speakers M. C. Shaw of M.I.T., W. E. Campbell of Afram Consultants, Cleveland, K. L. Berkey of Wright Air Development Center, C. K. Jones of General Electric, C. F. Kottcamp of Gulf Research and Development Center, and Arthur Irwin of Marlin-Rockwell Corp., Jamestown, N. Y. A tour of Wyman-Gordon's Grafton Plant is scheduled for April 14, and Past Chairman's Night on April 15 will include Ladies' Night at the Boston Museum of Science. . . . **Buffalo** — Dinner at Hotel Sheraton was followed by a talk on "Gears and Gear Lubrication" by Joseph H. Allen of Farrel-Birmingham Co., Ansonia, Conn.; Allen presented subject from viewpoint of customer-salesman relationship. . . . **Chicago** — Fifth meeting of 1957-58 season highlighted by Past Chairman R. A. Kraus' discussion of "The Function of a Lubrication Engineer in Industry." Annual golf party's date has been changed to June 12 at Cog Hill Golf and Country Club . . . **Dayton** — During February problem-solving session, Albert Lipton of National Cash Register Co. discussed importance of metal and lubricant combinations for successful worm gear operation of cash registers. Robert H. Guy of Detroit Transmission Div. of General Motors, Ypsilanti, Mich. presented paper on "Receiving, Storing, Handling and Distribution of Metal Working Fluids." . . . **Duluth-Iron Range** — Thirty-one members and guests heard February talk by Paul M. Kochensperger, master mechanic at Lakehead Pipeline Co. and Standard Oil of New Jersey, on "Diesel Engines and their Maintenance." . . . **Houston** — At March business meeting, nominating committee submitted names of nominees to take office in May. R. H. Howland of Briggs Filtration Co., discussed development of modern filters for modern requirements. . . . **Intermountain** — Section officers elected at February meeting are: Jack E. Bradley, chairman; Stanley A. Gudmundsen, vice chairman; James A. Kyle, secretary; Lorenzo Baldee, treasurer; M. W. Robbins, publication committee chairman; D. W. Richardson, membership committee chairman, and Glen S. Powell, section reporter. . . . **Hudson-Mohawk** — Dr. Eugene Merchant, research director at Cincinnati Milling Machine Co., spoke on "Metal Cutting" at March meeting. . . . **Los Angeles** — "Molybdenum Disulfide as a Grease Additive" was ably covered by Climax Molybdenum's Elwin E. Smith. . . . **Milwaukee** — Talk on "Octane and Octane Ratings" was presented by Royce Childs, superintendent of testing labs at Waukesha Motors. . . . **New York** — An up-to-date discussion of "Jet Age Lubricants" was provided by Charles T. Stone of Esso Standard Oil Co. A ten-minute talk on "New Oil Heats Gear Case" by S. Van T. Jester, Jr. of Gulf Oil was an additional feature of the February meeting. . . . **Northern California** — "New Developments in Gear Lubrication" were analyzed by Dr. Peter A. Asseff of Cleveland's Lubrizol Corp. at February meeting. March meeting consisted of a joint session with the Golden Gate Chapter of A.S.M. with E. M. Kipp discussing "Fundamentals of Wear and Friction." . . . **Ontario** — At February meeting, George Topel of S. F. Bowser Co., Ltd. described an oil conditioning system promoted by his company. March speaker W. B. Silvis answered his question of "How Good Are the New Type Motor Oils?" . . . **Puget Sound** — Dr. Asseff continued his trip through the West with a slide-illustrated talk on automotive gear lubricants.

Saginaw Valley — New officers elected on January 30 are: Joseph Small, chairman; William A. Mason, vice chairman, and D. H. Smallridge, secretary-treasurer. Education course a tremendous success (see below). . . . **Syracuse**—February dinner meeting featured talk on "Petroleum Base Rust Preventives" by Howard B. Carpenter, Esso Standard Oil Co. March bring-a-guest-meeting highlighted by discussion of "The Role of the Analytical and Testing Laboratory in Lubrication Practice" by R. J. Ronan of The Texas Company. . . . **Twin Cities**—Seventy-one members and guests heard T. P. Sands of Monsanto Chemical Co. speak on "The Current Status of Automotive Gear Lubrication."

Saginaw Valley Grows 200%

The recent six-week course in Lubrication Engineering has been reported highly successful by ASLE's Saginaw Valley Section. Jointly sponsored by the Mott Foundation and the Section, the course registered 46 people, six of whom were ASLE members. Registration fees for 1958 dues were included in charges to non-members.

As a result of education course activity, the Saginaw Valley Section has grown 200 percent.

Section members desiring help in planning membership campaigns or education courses should consult their regional vice-presidents.

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Hydraulic fluids
Fire-resistant hydraulic fluids
Gear lubricants
High-temperature lubricants
Low-temperature lubricants
Rubber lubricants
Packing lubricants
Compressor and Pump lubricants
Lift-truck lubricants
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These polyalkylene glycols and derivatives are available in both water-soluble and water-insoluble series, with or without additives. Viscosities of UCON fluids and lubricants range from 50 to 90,000 S.U.S. at 100° F.

UCON fluids and lubricants have a record of proved performance. Find out what they can do for you. Write for booklet 6500.

UNION CARBIDE CHEMICALS COMPANY

Division of UNION CARBIDE Corporation

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NEW EMOLEIN® 2910 LOWERS COST OF SYNTHETIC LUBRICANTS

Emolein 2910 Lubricant Ester, formerly designated Emery 3033-S, is the answer to lower-cost synthetic fluids and greases required by the jet age. In synthetic fluids, total cost can be reduced substantially by blending Emolein 2910 with an azelate diester without sacrificing performance. In greases, Emolein 2910 can be used alone or by blending with other fluids.

Emolein 2910 dipropylene glycol dipelargonate is a new type of diester based on inexpensive pelargonic acid. With performance testing having confirmed its utility, it joins the established members of the Emolein line of diesters, Emolein 2957 di-iso-octyl azelate and Emolein 2958 di-octyl azelate, whose performance under the conditions encountered in modern jet engines has given them a recognized position in the synthetic lubricant field.

One more important fact: The Emolein esters are *not* dependent upon imported raw materials. Since they are derived from abundant domestic tallow their future supply is practically unlimited. For more detailed information on Emolein 2910 or the Emolein azelates, return the coupon below.

Emery **ORGANIC CHEMICAL SALES DEPARTMENT**

Emery Industries, Inc., Carew Tower, Cincinnati 2, Ohio

West Coast: Vopcolene Division, 5568 E. 61st St., Los Angeles 22, Calif.
In Canada: Emery Industries (Canada) Ltd., 639 Nelson Street, London, Ont.
Export Department: Carew Tower, Cincinnati 2, Ohio

Emery Industries, Inc., Dept. Y-4,
Carew Tower, Cincinnati 2, Ohio

Please send bulletins:
- ☐ No. 411 (Emolein 2910 Pelargonate)
- ☐ No. 409A (Emolein Azelates)

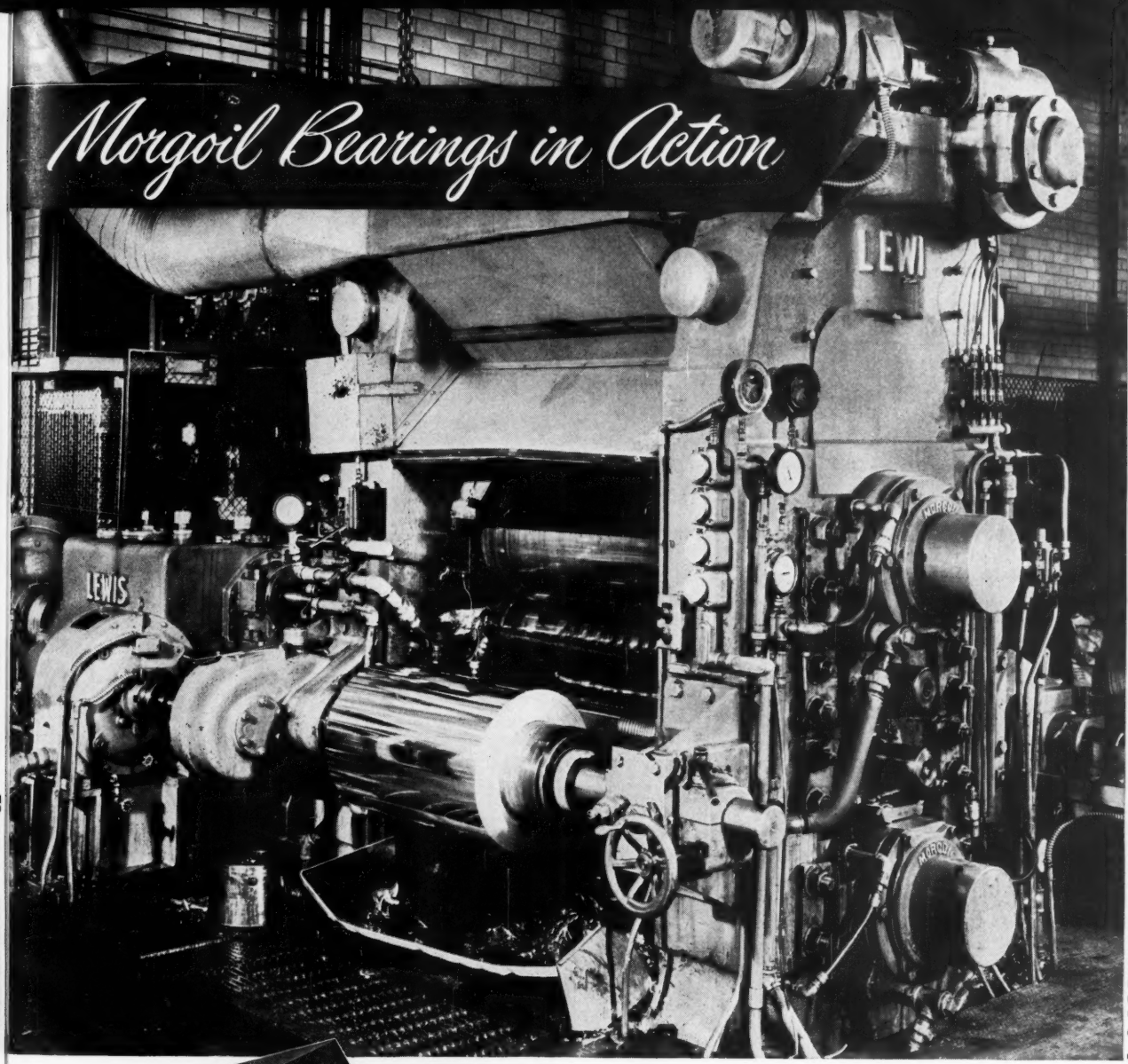
Name_____ Title_____

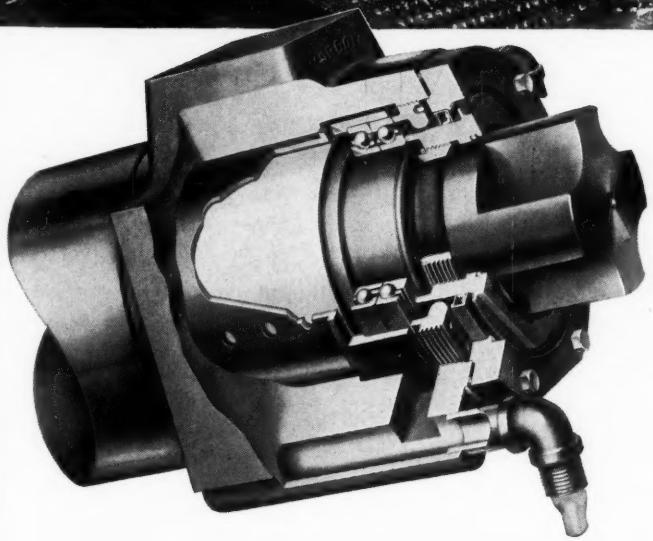
Company_____

Address_____

City_____ State_____

Morgoil Bearings in Action





The 18″-72″ MORGOILS on the 9″ and 21″ x 44″ Aluminum Foil Mill at Cochran Foil Co. pictured above make it easier to produce a quality product at high speed. Foil as thin as .00025 of an inch is rolled at speeds approaching 4000 feet per minute on MORGOIL-equipped mills. MORGOIL BEARINGS give you freedom from wear and fatigue and permit operation at high speeds with remarkable long bearing life.

MORGAN CONSTRUCTION CO.

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ROLLING MILLS MORGOIL BEARINGS GAS PRODUCERS
WIRE MILLS EJECTORS REGENERATIVE FURNACE CONTROL

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"In 14 months...not a single bearing lubrication failure with lithium-base grease!"

Conveyor-stacker handling moist, sticky material which builds up on the rollers.

Ore unloading conveyor rollers handling 200 tons of ore per hour.

Pinion gear transmitting power from 600 h.p. motor to a ball mill.

Pan Conveyor handling hot clinker (1600°F), roller bearings in dusty, moist atmosphere.

Leach tanks handling hot slurry, agitators driven by Falk gear reducing units.

V.A. Wemco classifier, part of wet grinding system, lower bearing submerged in hot sludge.

THE PROOF IS IN THE PERFORMANCE...

lithium-base grease does the job...

and does it better!

Here's a report of our own experience with lithium-base grease under extreme industrial service conditions. Approximately 95% of the grease used in the plant of AMERICAN LITHIUM CHEMICALS, Inc., our subsidiary at San Antonio, Texas, is lithium-base, one-type grease. In fourteen months operation we have not been able to trace a single cause for bearing failure to the lubricant used. The on-the-spot photos above give graphic evidence of the rugged bearing service requirements in this plant where lithium ores are processed into high-grade lithium hydroxide, itself an important ingredient in lithium-base grease. Performance like this is why grease chemists, manufacturers, marketers and users all attest to the superiority of lithium-base... the *one* grease in place of *many* for efficient and economical operation.

Want to know more about TRONA lithium hydroxide monohydrate? Send for our technical bulletin on this important chemical ingredient in lithium-base greases.

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Lube Lines

by A. F. Brewer*

Today in Lubrication

The current interest in producing more people of technical and scientific ability has had some interesting repercussions. Statistically, some say that we are short on scientists. Practically, some of these statistics would seem to be refuted. More accurately, it could perhaps be suggested that best usage is not being made of available talent. It is all very well for some critics to date their arguments back to the curriculum of the elementary school stage, or to high school practices of emphasizing sports over scholastic ability, even to the extent of ceasing to offer mathematics and science courses. That is the path of least resistance. Let's be more constructive and factual. In reality industry itself might well share some of the responsibility. Too often graduates of recognized technical schools have been hired and then allowed to stagnate somewhere in routine work with the idealistic thought that they are being "trained."

Let's look at the field of lubrication, for example. No company or plant engaged with the operation of machinery can do without lubricants. They are as indispensable as the bearings, gears and other mechanisms which they protect. But there are still too many plants where the responsibility for the usage of lubricants is relegated to some uninformed worker, while trained engineers in the office may be occupied with routine details which are often a far cry from their education and training.

Would it not be better to pick one of these main office technical people and make better use of his ability by giving him responsibility for plant lubrication? His knowledge of office management could very well be extended to the plant and to the organization of a lubrication program. Possibly in the office he became aware of the cost of the machinery in the plant; possibly also he might have noted the marked difference between the cost of lubricants consumed annually and the cost of replacement parts. Give him a chance to prove the true value of lubrication as a service factor, not just as a means of using up lubricants. To cite an example:

Once upon a time there was a trained mechanical engineer who was assigned to the routine duties of tabulating operating costs of plant machinery and keeping boiler efficiency records. Meanwhile this machinery was operating on several dozen types or grades of lubricants, each department ordering and using products without much regard for their suitability for similar machinery elsewhere in the plant. This was before the age of simplified lubrication, so perhaps the custom was pardonable.

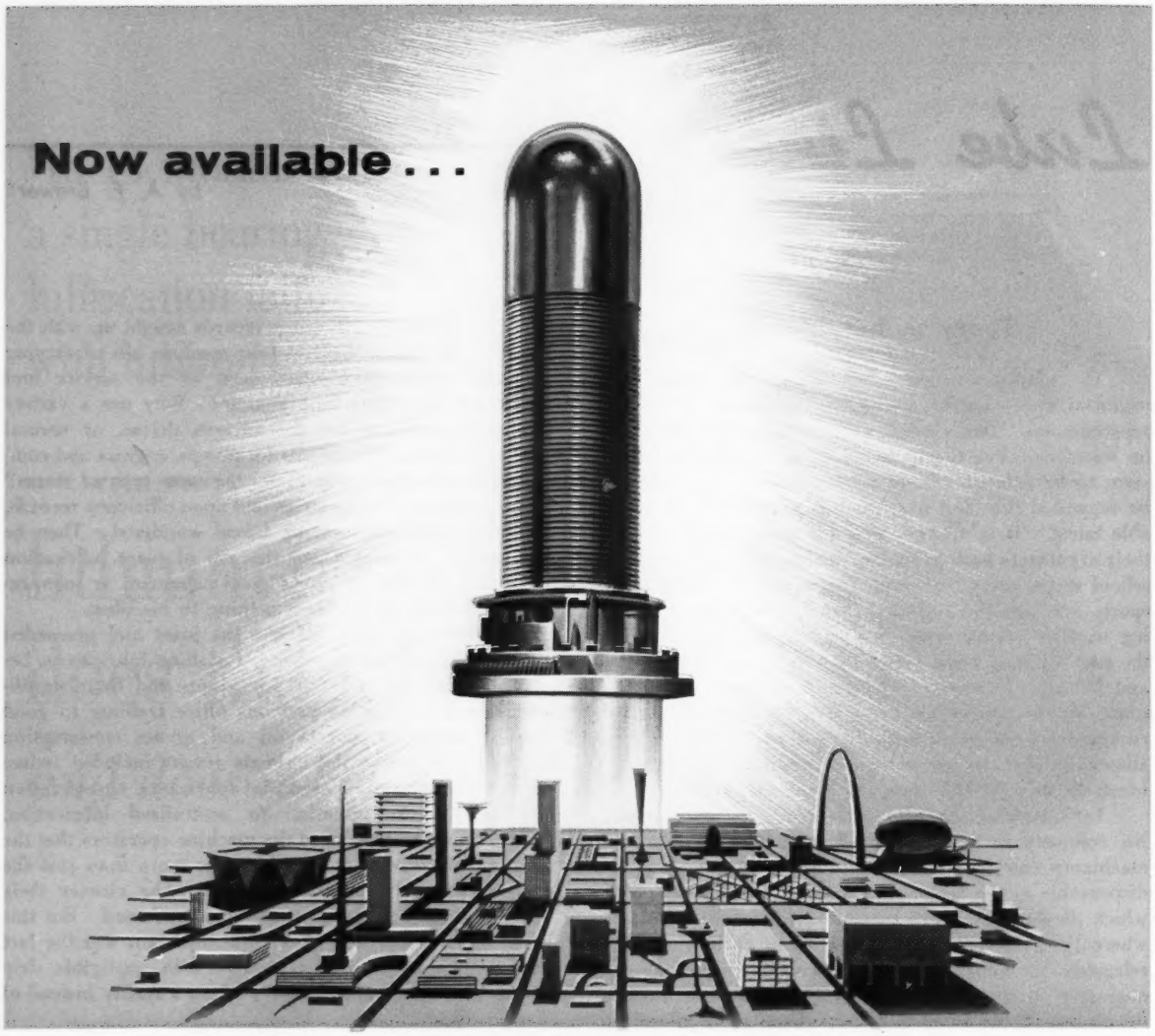
But finally the efficiency records caught up with the parade. Why were three or four machine oils of varying viscosity being used when most of the service and structural conditions were similar? Why use a variety of heavy gear oils for the various drives, or several grades of steam cylinder oils for pumps, engines and compressors operating on virtually the same type of steam? Being familiar with the stress laid upon efficiency records, our mechanical engineering friend wondered. Then he did more. He sought out the job of plant lubrication engineer. Maybe he was a good salesman, or management felt there might be something to his ideas.

Anyhow he went out into the plant and proceeded to study lubrication first-hand, installing lubricators, becoming familiar with test procedures and their significance, and putting his previous office training to good use by keeping accurate oil and grease consumption records. Logically, the ultimate results included reduction in the number of grades of lubricants, consolidation of usage, more attention to centralized lubrication. Furthermore he convinced the machine operators that the relation of cleanliness to safety was more than just the subject for bulletin board posters. The cleaner their machines, the less oil or grease was consumed. But this was only a minor benefit. More important was the fact that better machine performance with negligible drip would result and safety would become a reality instead of just an ideal.

We could go on to state that ultimately our hero became president, but this is not the purpose of our story. Yet, let's look at the possibilities. Why shouldn't the lubrication engineer raise his sights? Certainly he should be as conversant with machine design, operation and maintenance as anyone else in the company. In fact, he should be more conversant with the relation of dependable machine operation to low-cost production and earnings. Certainly, also, he should know the significance of tests and specifications of materials and how much importance should be attached to them in purchasing. To sum up, his overall value to management can be virtually inestimable.

So in the interest of most effective utilization of technical manpower, it is not too extravagant a statement to say that the lubrication engineer has a definite place in management. And, when he does attain the objective of managerial responsibility in his company, he can carry the ball a long way in behalf of his colleagues who are interested in broadening the field of lubrication. The example set by his company's appreciation of the scope and value of his knowledge should emphasize the benefits to accrue from enlisting managerial interest in effective lubrication and in utilizing the technical ability of the lubrication engineer to full advantage.

*Consultant, and author of *Basic Lubrication Practice.*



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LUBRICATION ENGINEERING

RESEARCH APPLICATION EDUCATION MAINTENANCE

Journal of the American Society of Lubrication Engineers *Vol. 14 No. 4 April 1958*

FUTURE PATHS

Past years have seen ASLE progress along a path of formal organization and expansion. Among the major accomplishments which have made ASLE a going concern are:

(1) Formation of technical committees, each with various subcommittees functioning to promote a broad scope of activities and interests for the lubrication engineer.

(2) Publication of *Lubrication Engineering* as a monthly journal.

(3) Expansion of the activities which provide technical information to the lubrication engineer, including groups which furnish abstracts, summaries of foreign papers, patent abstracts, and in addition provide technical papers dealing extensively with lubrication practices. Yet the number of papers which treat theoretical and research accomplishments have not been diminished.

(4) Methods of answering requests for specific consultation on problems which are difficult for practicing lubrication engineers to resolve. This has been achieved by the establishment of information subcommittees within each technical committee.

(5) Education of lubrication engineers in the science and related fields by means of special courses set up by the Society. Standardization and joint sponsorship with colleges and universities throughout the country of course presentations in the field of lubrication.

All of these accomplishments were once goals. They make our tasks lighter and more productive.

There are a number of paths a professional society may take to serve its members. The rapid growth of ASLE in recent years speaks well of the wisdom of the members who served as directors. With the period of formal organization behind us, we can clearly determine the value of past accomplishments. Even more apparent, however, are the paths still to follow to solidify our financial position and gain professional recognition for the lubrication engineer *by all segments of industry.*

Technical committees of ASLE have been instrumental in completing those projects most essential to the lubrication engineer. The projects have been approached from a material or equipment point of view. Formal organization of industry councils now permits the members to define and help solve the problems which affect a particular industry.

Five such councils are functioning; more should be formed. Each industry should be represented in ASLE by an industry council. To make this possible, we must gain acceptance and recognition of the lubrication engineer's vital role in industry. We must provide each industry with methods of improving productivity.

This goal cannot be attained by our technical committees and industry councils alone — industry must accept the role of full-time partner. In exchange for the coordination, experience, manpower, and know-how available through the Society, industry must assist with the funds and material goods required to solve the problems.

Another path is well defined. We must expand those activities which produce operating revenue for the Society. If we create recognition and acceptance of the lubrication engineer's function in the specification, selection, and approval of the "productive maintenance" equipment, materials and services which he buys, we will attract more advertising revenue to our journal. Increased revenue will permit expansion in research activities and pay for those services which cannot be self-sustaining.

It is proper that a professional society should seek industry's assistance. It is especially right that ASLE should seek such help, for ours is a society which was founded to serve industry.

By providing a suitable publication to communicate the message of those who would sell to the industries that we represent, we educate the lubrication engineer to the tools and services available from the supplier. The funds derived from this advertising are instrumental in expanding ASLE services to industry and the consumer.

With expansion of the Society's revenue producing activities, we will be better able to undertake more projects which are not self-sustaining, but which contribute immeasurably to the intangible benefits of ASLE Membership.

I would like to remind you that the success of the president of any organization is largely dependent upon the support of the membership. With the support and active cooperation of every member of ASLE, which I actively solicit, the year ahead of us can be our most successful one.

J. D. Lykins, *President-elect*

Increased Machine Productivity Demands Well Designed Lubrication Practices

Robert H. Guy, Detroit Transmission Division, General Motors Corporation, Ypsilanti, Michigan

Improvements in metal alloys have enabled machine builders to design more productive tools. Hydraulic and electrical improvements have allowed them to interlock machine components for greater labor savings. Efficiently designed automatic lubrication, modern petroleum storage and dispensing methods, in association with thoroughly trained maintenance personnel, will result in the maximum production return from this newer style equipment. Preventive maintenance programs and accurate cost studies must be followed continually to receive major benefits from the large capital investment required to automate production processes. Lubrication science must be extended to answer the new problems involved and machine buyers must take advantage of all improvements to be competitively active in today's and future markets.

The problems confronting any plant lubrication engineer are compounded when machine components are combined by means of transfer elements for higher productivity per man-hour. Increased metallurgical and machine design knowledge has enabled builders to erect longer, stronger, more efficient machine tools that operate at speeds that were unthought of in the prewar era. Tooling advances have resulted in more pounds of chips removed per unit of time. Each integrated machine becomes infinitely more important than the single tools it replaced, since any downtime means a complete loss of a production part.

Consequently, the lubrication engineer's task has increased in scope, responsibility, and variety. Now he must have an interest in and understanding of each of the fields of machine design, petroleum product manufacture, and lubricant application. It behooves the engineer, therefore, to alert each of these fields to the advances being made by their associates. Coordination engineering by the lubrication engineer is imperative if the machine buyer is to obtain the greatest profits from his investment. The lubrication efficiency of a classical single station machine tool was dependent upon the builder's ability and on the amount allocated by the builder which would be controlled by competition. Usually the cost of the system was incorporated in the quoted standard price. On transfer or specially designed equipment, the lubrication system is itemized as an accessory, and thus the expense of efficient oil or grease application is called to the attention of management. By frequent requests and suggestions to the device manufacturers to improve their engineering and by requesting the machine tool builders to incorporate design changes that will allow optimum use of lubricant devices, the lubrication engineer can justify economical, dependable lubrication to management.

Cooperation Between Machine Builder and Buyer

The advent of integration brought closer cooperation between tool builders and machine buyers. The annual model change deadline means that all means of saving time must be employed. One method is the "prequotation" conferences. These conferences allow the machine builder representatives, the process engineers, the plant engineers, specialists, lubrication engineer, tool control and production personnel to thrash out over the table all foreseeable problems before any construction is started. Certain questions must be asked by the lubrication engineer and realistic answers returned before preliminary approval can be given. They are:

1. Are the loads and speeds such that one lubricant will satisfy?
2. Are the points of lubrication reduced to a minimum?
3. Are all the ambient conditions considered in selecting the lubricant type and lubricating method?
4. Are the lubricant devices of proven engineering?
5. Is the coolant system adequately controlled?
6. Are the Lubrication Standards for Industrial Equipment and the Application Standards for Cutting Fluid Devices rigorously followed?
7. Does the cost per lubrication point, including design cost, fall within the "rule of thumb" range?

Being alerted to these points, the builders' representative must transmit the information to his design personnel. Any deviations from the Lubrication Standards or variances from the suggested points must be covered in writing. The plant lubrication engineer is familiar with his corporation's and division's policies and procedures. The purchasing of lubricants by specification, as much as possible, is part of the procedures. In any one plant, the combination of purchased specification and "trade name" lubricants has proven its ability to maintain the many types of machine tools in use. Therefore,

MACHINE REPAIR RECORD

MACH. NO.	MACH. NAME	MODEL NO.	SERIAL NO.	DEPT. NO.
0001	EXCELLO	2112 A	X 41321	508

CODE= A-ADJUSTMENT CO-CARELESS OPERATOR H-HYD. LEAKS
D-DIRT & CHIPS IL-IMPROPER LUB O-OUT OF OIL WP-WORN PARTS

DATE	CODE	HRS. REQ.	ACCUM. HRS.	MATERIAL USED	REMARKS
3-5-54	WP	1	11 (10)	B-303 V-BELTS	
32554	H	3	14		

Figure 1. Machine breakdown cost card.

USAGE RECORD

CODE NO. 24		CODE NO. 5		CODE NO.	
DATE	AMT.	DATE	AMT.	DATE	AMT.
10-8-53	17	3-15-54	1/2		
1-22-54	2				
3-15-54	1				
3-27-54	1				
4-4-54	17				

MACH. NO.	TYPE	DEPT.	LOCATION
0001	EXCELLO 2112 A	508	

Figure 2. Machine oil usage card.

with his plant's experience as his background, the lubrication engineer must be the arbiter of the proper method of application and the lubricant to be used. The machine tool builder must concur and, in some cases, change the design or his thinking to accommodate the plant practices.

Proper Lubricant Handling Facilities

The author's company has relocated physically twice in the last five years. In 1952, it moved from the old, six story plant on Riopelle Street in Detroit to a modern one floor plant in Livonia, Michigan. A disastrous fire in 1953 forced another move, this time to the famous B-24 plant at Willow Run. In 1950, the lubrications group began to improve oil handling methods. With each plant move, the petroleum handling facilities were extended and amplified. These facilities now consist of an underground tank farm with fifteen and a half thousand gallon tanks, automatic pressure demand shallow well pumps in each, and an overhead piping system that extends throughout the manufacturing area. Almost every machining tool has its recommended cutting oil piped directly into its coolant reservoir. Since most departments use each of the volume cutting fluids, it is a simple task to re-pipe in the event a tooling change necessitates a fluid change. This practice of piping directly to the machine is used for hydraulic oils and machine lubricants if the size of the reservoir is over 150 gallons. If a transfer type machine is leaking badly, we find it advantageous to install a meter in the oil supply line to determine just how "bad" is badly. Careful collection of oil records by stations for one or two days will segregate the malfunctioning stations and allow the repairman to narrow the area of his visual search.

The pipe line system's main headers were constructed of two-inch pipe with welded fittings and connections. Each pipe was labeled every 200 feet and at floor level to minimize pipe fitters' mistakes when the sub-mains and feeder lines were extended to individual machines. Several oil depots equipped with shut-off valves, oil resistant rubber hoses and gasoline-type nozzles were installed at strategic locations throughout the plant so that any personnel may draw oils from the lines for small usage applications. The criteria is used that any oil purchased in the amount of 4,000 gallons or more per month can be incorporated economically into our tank farm. The price differential between tank car and barrel deliveries is usually enough to reduce the capital investment required.

A parallel piping system also handles waste oil products. Oil that is vacuumed off the floor or out of machine reservoirs is dumped into sumps. Pumps that are controlled by automatic level floats supply the energy to return the waste oils and emulsions to the Reclamation and Disposal House. There, the mineral oils are combined with the wastes centrifuged from our chips and processed for reuse; the emulsions, or materials contaminated with too high a percentage of water, have the oily phase concentrated and are commercially disposed. An ingenious pressure differential piping design ensures that plant needs will be satisfied by reclaimed oil, and that new oil will enter the system only when makeup is needed.

The central fluid system of an integrated line must be discussed carefully during the pre-quotation conference, since the system must regenerate the fluid as completely as possible to keep maintenance costs low. The filtering method selected should be suitable for the machining operation and should be either the self-cleaning or back-wash type. The pitch of the coolant return trough and the reservoir design are critical in order to localize the dropping of chips onto the automatic drag-out conveyor with no dead spots. Most reclamation and disposal systems of 1953 vintage or before are not capable of assimilating sudden increments of several thousand gallons of oil or emulsions when pits are cleaned. A large enough holding tank to spread the load over many hours must be installed. Therefore, many benefits can be derived from decreasing the cleaning frequencies of coolant systems.

Controlled Lubrication Maintenance

Because of the costliness of unscheduled downtime, some means of controlling the maintenance of "in line" machines must be selected. It is logical to mechanize the machine lubrication and coolant change schedules by employing automatic business machines which are commercially available. In our division, machine lubrication is a function of the machine repair department under the master mechanic, whereas the coolant control is the responsibility of our plant engineer's department. A flip card file is used by Machine Repair to accurately record the breakdown costs of each machine. Also, this department instituted a job ticket method of scheduling lubri-

LUBRICATION RECOMMENDATION

LEGEND

MACH. NAME EXCELLO 2112 A — HO-HAND OILED GC-GREASE CUP
MACH. NO. 0001 — AF-ALEMITE FITTINGS
DEPT NO. 508 — SFOC-SIGHT FEED OIL CUP
BAY NO. — MOL-MAINTAIN OIL LEVEL
CL-CENTRALIZED LUBRICATION

LUB PT.	PARTS	METHOD OF LUB	LUBRICANT DTD NO.	FREQUENCY OF LUB.	FREQUENCY OF INSPECT.
1	HYD. RESERVOIR	M.O.L.	24	6 MO. CHG.	DAILY
2	LUBE TANK	M.O.L.	5	6 MO. CHG.	DAILY
3	TENSION PULLEY	A.F.	91	6 MOS.	

Figure 3. Recommendation card for proper machine lubrication.

LUBRICATION RECORD

DATE REQUEST	DATE FORE. APPR.	LUB POINT	ESTIMATED TIME	DATE COMPLETED
4-1-54		1-2-3	2.5 HRS.	4-4-54

Figure 4. Record card to post periodic machine lubrication.

cation operations, the information then being easily transferred to the card file. Figures 1, 2, 3 and 4 are reproductions of the forms used in the file to develop for management a picture of any machine's condition and "keep running" costs. Excessive short time repairs or lubricant usage that becomes evident upon recording in the file may indicate the need for a major machine investigation to forestall a major breakdown.

Controlled Coolant Maintenance

Since coolant change records are more of a "go" or "no go" importance, the plant engineering department elected to use punched card facilities to act as its "memory." A discussion of the method by which the automatic business machines present only those cards for the night's work is not in order here, but the oil and compound foreman is supplied with a deck of cards for each night's work load. The cards are divided among the employees and, upon completion of the task, are used as the authority to check the operation off a master sheet. Our procedure states that if an unscheduled coolant change is necessary, it must be authorized on a special form. After the change is made, the form is relayed to the lubrications office for investigation. The least possible time is lost before correcting an unstable coolant or situation. From the preceding, it is evident that machine lubrication is controlled at the point of application, whereas the coolant usage is controlled by the frequency of drain.

Educate the Personnel

Exacting control of lubricants, coolants and methods is necessary since the oiler or oil and compound man has been classed only a short step ahead of a sweeper or wash-room attendant in the automotive industry. This philosophy has shown indications of change. In any case, an educational program is invaluable. Naturally, the emphasis is with the oiler and coolant personnel, but our experience has shown that the production foremen and personnel, skilled tradesmen and engineering people must also be reached. In the author's company, the oilers attend formal classroom training sessions for a total of 100 hours. Job methods, lubricant specifications, lubricant device principles and job responsibilities are covered. The education of the other groups is more difficult because it must be casual but definitive. We do not think this phase of lubrication education will ever end. The results of the class room training were astounding. The oilers were the only group in an hourly classification that received any specialized training and their morale was high. On the production floor, they became the disciples of proper preventive maintenance.

SUMMARY

From the viewpoint of lubrication engineering, the changeover from multitudinous single machine tools to integrated lines has been successfully hurdled. After a year and a half, there is a higher production rate with less machine breakdowns and fewer oiler and oil and compound personnel. Our lubrication and coolant costs are accurately reported each week, allowing management to make significant moves to lower production costs. The utilization of commercial lubrication devices by the machine tool builders of transfer lines has proven their worth beyond any doubt, especially when compared to single station tools with their infinite variety of lubrication philosophies.

The manufacturing process of one of many transmission parts includes sizing, facing, milling, drilling, tapping, reaming, heat treating, honing, sub-assembling and then dynamically balancing containing oil, and disassembling, to drain the oil. The entire process is performed on one machine. Four machine tool builders cooperated in the erection of this machine. With such evidence, the inevitably of integrated lines is proven. The science of lubrication must expand to include the problems arising from such tool building. The "oily film" should not be the weakling in the chain of high productivity per unit investment.

Fifth Annual ASLE-ASME Joint Lubrication Conference

October 13, 14, and 15, 1958 — **Hotel Statler, Los Angeles, Calif.**

Treatment of Oil Wastes from Machining Plants

M. F. Madarasz, Ford Motor Company, Dearborn, Michigan

Industrial participation in preserving the water resources is exemplified by the many industrial waste treatment plants. However, the rapid increase in industrial growth and oil usage indicates additional facilities may be necessary.

Adequate planning in initial design phases will minimize the loss to sewers and can reduce the size of treatment plants. Treatment of waste oil can be divided into two main categories: (a) batch and (b) continuous. The treatment facility at a Cleveland engine plant is designed to handle 1,000 gallons per minute. Provisions have also been made to treat batch wastes of emulsified oil containing 5 percent ether soluble material. Facility includes surge basin, batch treatment tank, clarifier and sludge lagoons. Treatment of batch wastes is accomplished by preliminary treatment with calcium chloride. Partially treated waste and continuous waste is treated by the addition of 40 percent ferric chloride solution and lime. Resulting sludge of iron hydroxide containing the absorbed oil is discharged to the lagoons for dewatering. Clarified effluent is discharged to public stream.

Efficiency of treatment is indicated by results of preliminary laboratory tests. Plant effluent analyses indicate an average of 17 parts per million of ether-soluble material. Substantial economy is a result of using only acid-resistant materials for only ferric chloride storage and feeding equipment.

Due to the successful results obtained three additional plants have been designed on the same basis with equally good results.

Industrial participation in preserving water, one of the main resources of this country, is exemplified by the many waste treatment plants that have been built by industry.

These plants treat many various waste waters containing such contaminants as cyanides, chromium, acids, alkalies, solids and oils. Of these many wastes, the treatment of waste water containing oils has received much attention.

It can be readily anticipated that additional industrial waste treatment plants will be required due to industrial growth and increased oil production. Production of oil in 1956 was about 7.9 million barrels per day and will reach between 13 to 15 million barrels per day by 1965 (1).

In 1946, the author's company, in conjunction with its expansion program, included the construction of industrial waste treatment facilities for all new plants. Manufacturing plants not producing objectionable waste-bearing waters were designed to include a separate process sewer for any future changes in processing which may necessitate a waste treatment plant. However, it also included in the over all planning necessary measures to minimize oil losses, recognizing the all important fact that waste treatment facilities should be constructed only for those wastes which cannot be economically eliminated from the process sewers.

Generally, the conservation measures include: filtration, sedimentation, preventive maintenance to minimize oil leaks, confining oil operations by placing machines in individual pans or oil-tight areas, and bacteriological control of coolants which may become rancid or foul smelling without disinfectant control. To detail the con-

Figure 1. Waste treatment plant.

servation measures and their application is beyond the scope of this paper, as it in itself is a major topic.

In machining plants, the problem of treating oil-bearing waste water can be complex due to the varied operations requiring different oils and coolants. The waste water may contain lubricating oil, cutting oils of various blends depending on its original use, coolants which are either of the soap or synthetic detergent type, or a combination of all when collected in a separate process sewer system for treatment.

Oil losses can be readily classified into two major types: (a) batch discards (b) continuous waste water. Batch discards are emulsified coolants and are usually a result of mechanical breakdown of collection equipment in sedimentation tanks located in the manufacturing plant. The continuous waste water containing oil is derived mainly from washing and cleaning operations on parts prior to or after processing as the case may be.

DESCRIPTION OF A WASTE TREATMENT PLANT

Described herein is a waste treatment plant (Fig. 1) to treat oil-bearing waste water from one of two engine plants located in Brookpark Village near Cleveland, Ohio. Waste water from the other engine plant is also treated similarly. The treatment plant is designed to treat 1,000 gallons per minute of continuous waste water containing 500 parts per million of ether-soluble material. It is also designed to effect primary treatment on a batch basis of 30,000 gallons of discarded coolant containing 20,000 to 50,000 parts per million of ether-soluble material.

A flow diagram of the oil-waste treatment facilities is shown in Fig. 2. The treatment plant consists of six main components: (a) operating building, Figure 3, (b) surge basin, Figure 4, (c) holding basin, Figure 4, (d) clarifier, Figure 5, (e) ferric chloride storage tank, and (f) sludge lagoons, Figure 6.

The operating building is integrated with the surge and holding basins. The building houses two 1,000 gallon per minute pumps, a 0.25 and a 2.5 million gallon per day rate-of-flow controller, a lime feeder, two ferric chloride feeders, and level indicators for the surge basin and holding basin. A laboratory bench is also included to enable the operator to make miscellaneous tests.

Plant Operation

During normal operations the waste water flows by gravity from the manufacturing building to a sump located at the operating building. From the sump, the waste water is pumped to the surge basin which has a capacity of 60,000 gallons and provides means for minimizing the variations in volume and concentration prior to treatment. The one hour retention time in the surge basin also enables most of the free oil to rise to the surface. This is skimmed off periodically by means of a manually adjustable slotted-pipe skimmer. The skimmed oil is drained to a skim oil tank located below the floor of the operating building. Continuous waste water then flows by gravity from the surge basin through the larger rate-of-flow controller at a predetermined rate to the clarifier for chemical treatment.

Batch discards occur very infrequently and are normally discarded during non-production hours. These discards containing as much as 50,000 parts per million of ether-soluble material are discharged into the same process sewer used for the continuous wastes during normal production hours.

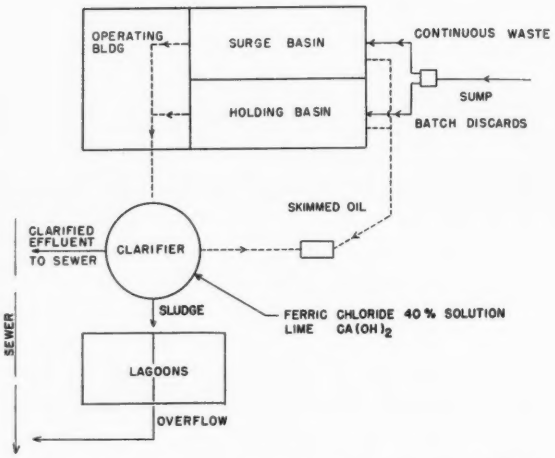


Figure 2. Flow diagram of oil waste treatment facilities.

The concentrated waste as received in the sump at the operating building is diverted by manually operated valves on the pump discharge pipe to the 30,000 gallon holding basin. The 30,000 gallon basin is sized to hold the equivalent capacity of two coolant systems in the manufacturing building. Initial chemical treatment involves adding 15-30 pounds of calcium chloride (dry basis) per 1,000 gallons of waste coolant in the holding basin and agitating with two large mixers for approximately one hour. After mixing, the waste is allowed to stand for approximately 8 hours or longer, if necessary, under quiescent conditions to permit the separation of the oil and water phase.

Selection of calcium chloride for initial treatment of batch discards was based on two main considerations. First, laboratory tests made on various coolants gave results which substantially were the same as published by Eldridge and Purdy (2), indicating that calcium chloride was more effective than sulfuric acid for splitting various emulsions. It was also determined on a laboratory basis that where calcium chloride was ineffective for breaking emulsions, other electrolytes were also without effect. Further laboratory investigations (Table I) showed that ferric chloride and lime were effective in the treatment of continuous waste waters containing oil and were also effective in the removal of ether-soluble material from high detergent types of coolants. Secondly, the use of calcium chloride in lieu of acid for breaking the emulsions would eliminate acid resistant equipment, thereby reducing the cost of the treatment facility.

TABLE 1. EFFECT OF TREATMENT WITH FERRIC CHLORIDE AND LIME

p.p.m. $FeCl_3$	pH (Lime)	Detergent Coolant*	Continuous Waste water*
		After Treatment	
100	8.5	326	—
200	8.7	36	4.0
300	8.7	36	—
400	9.0	12	8.0

*Average of 5 separate tests. Initial ether-soluble concentrations 500 parts per million.

Figure 3. Operating building.

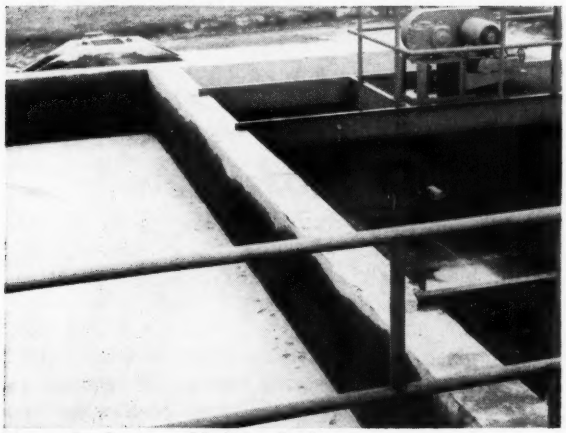


Figure 4. Surge and holding basins.

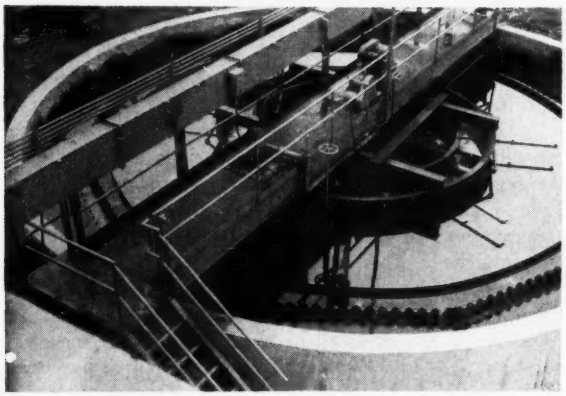


Figure 5. Clarifier.

Figure 6. Sludge lagoons.

After separation of the oil and water phase, the oil is skimmed from the surface in the holding basin by a manually operated skimmer pipe which is a duplicate of the skimmer arrangement in the surge basin. The skimmed oil is then drained to the skim oil tank. The water phase containing less than 3,000 parts per million of ether-soluble material is drained from the holding basin through the smaller rate-of-flow controller and blended with the continuous waste water being drained from the surge basin for treatment into the clarifier.

The clarifier has an internal diameter of 37 feet, with a side wall depth of 16 feet. It is of concrete construction and provides a detention time of 2 hours or a rise rate of 1.15 gallons per minute per square foot at the designed rate. The clarifier is complete with mixer, sludge collection mechanism, sludge recirculating pump and skimmer pipes in the mixing and settling zones. Also included is a mechanism for automatic blow-down of sludge from the recirculating system and an oil baffle on the periphery of the tank to retain any floating oil from passing over the circular serrated V-notch weir.

Chemical treatment is accomplished in the clarifier by adding ferric chloride solution (40 percent) and lime slurry to the mixing zone. Ferric chloride is added at a rate of 48 gallons per hour for 1,000 gallons per minute of waste flow, which is equivalent to 400 parts per million of ferric chloride (100 percent). Lime slurry dosage is approximately 400 parts per million varied not to exceed a pH of 10. The resulting iron hydroxide "flocc" formed by the addition of ferric chloride and lime absorbs, the oil from the waste water and the "flocc" then passes from the mixing zone to the flocculating zone to enlarge the "flocc." The "flocc" is then routed from the flocculating zone to the settling zone where the settled sludge is collected to the center of the clarifier and then drained to the sludge sump located under the operating building. The sludge is pumped to one of two earthen lagoons for additional dewatering.

Sludge samples taken from the lagoon vary considerably in dry solids content, depending on storage time in the lagoon and the depth at which the sample was obtained. Average analysis of the sludge samples is 35 percent dry solids of which approximately 40 percent is ether extractable.

Each earthen lagoon has a total effective capacity of 250,000 gallons and a swivel pipe inlet common to each lagoon. The lagoons are provided with stop plank outlet arrangements to maintain proper levels and avoid the loss of any sludge to the sewer. Lagoon use is alternated to further compact the sludge and allow for some evaporation. After the lagoon has filled with sludge it is clammed out and hauled to a suitable dump area.

Effectiveness of the treatment is clearly indicated by the analysis of the treated effluent from the waste treatment plant. Average ether-soluble content for a recent two week period is 17 parts per million with a maximum of 25 and a minimum of 6.

SUMMARY

Industrial expansion and increased oil consumption has necessitated the installation of waste treatment facilities to prevent stream pollution. Proper engineering planning and preliminary laboratory data can provide a treatment facility without extensive corrosion materials and equipment. *(Cont. on p. 164)*

Design and Testing Consideration of Lubricants for Gear Applications

Eugene E. Shipley, Gear Engineering,
General Electric Co., Lynn, Mass.

The tendency in the gear industry today is toward high capacity gearing. More load, less weight and higher speeds have been stressed to such an extent that many gear designs are completely dependent on the lubricant available. In effect, the lubricant has become a constructional gear material.

The real block to higher load carrying capacity seems to be an inadequate understanding of the lubrication phenomenon.

Work has been done to investigate the types of gear failures related to the lubricant, namely, wear and scoring. The following report covers some of the procedures and tests used in evaluating a given oil for gear applications.

INTRODUCTION

From a gear engineer's point of view, a good lubricant should have the following characteristics: low cost, low volatility, lubricity, thermal stability, oxidation stability, hydrolytic stability, good viscosity — temperature characteristics and ready availability.

In general terms, the oil supply for any given gear design need not have all of the above characteristics, but the lubricant must perform the functions of satisfactorily lubricating the gear mesh to prevent wear and scoring, controlling the gear blank temperatures, and adequately serving as a lubricating medium for the bearings.

The tendency in the gear industry today is toward high-capacity gearing. More load, less weight, and higher speeds have been stressed to such an extent that many gear designs are completely dependent on the lubricant available. In effect, the lubricant has become a constructional gear material (1)[1]. Gears fail in service, generally, from pitting of the gear teeth, breakage of the gear teeth, long range wear and scoring. Most gear manufacturers have the capacity and machinery to produce gears of the accuracy required to run under high loads and speeds. Gear engineers have the experience and fundamental background to prevent these gear designs from failing due to pitting and tooth breakage. Knowledge and know-how concerning wear and scoring prevention is quite limited, however, and consequently, the real block to higher load carrying capacity is an inadequate understanding of the lubrication phenomena.

Presented before the 11th Annual Meeting of the ASLE, Pittsburgh, Pa., April 4, 1956.

[1]Figures in parentheses refer to bibliographic listings at the end of the paper.

GEAR FAILURES — GENERAL

Gear wear and gear scoring have been a problem to the engineer for a long time. Some phases of the industry have been plagued with this more than others. The aircraft industry, for example, was able to design around these limitations and was confronted with more urgent problems such as tooth breakage and tooth pitting.

A tremendous amount of testing was required to partially solve the pitting and breakage problem. While this work was being carried on, the ever-present wear and scoring phenomena kept creeping into the picture. Wear was evident at low speed operation, and both scoring and wear were present at high speeds. When the teeth were loaded high enough for tooth breakage, scoring was particularly evident.

Figure 1 shows a plot of pitch line velocity vs torque capacity of a gear set (2). The various areas indicate the regions where gear failures are more apt to occur. From Figure 1, it is quite evident that as speed is increased, the region where scoring becomes predominant is approached. This is further aggravated when the load and speed are increased simultaneously. Area 3 in Figure 1 can be moved higher and further to the right by using better grades of oil or by the use of extreme-pressure additives in the same oil. This technique has been used extensively in the field.

The curves in Figure 2 are gear test results whereby the load-carrying capacity with respect to tooth pitting was doubled by the use of a higher viscosity lubricant.

Initially, it was possible to carry approximately 250 K-Factor as shown by the bottom curve in Figure 2. When the gear lubricant was changed, the load-carrying capacity was increased to 500 K-Factor, as shown by the middle curve.

The general opinion is that pitting is a surface fatigue phenomenon, and as such, should not be affected by the lubricant used. However, the lubricant does indirectly affect the surface stresses, since a poor lubricant will allow a gear to wear and score. This breaks down the involute profile. The gears then run rough,

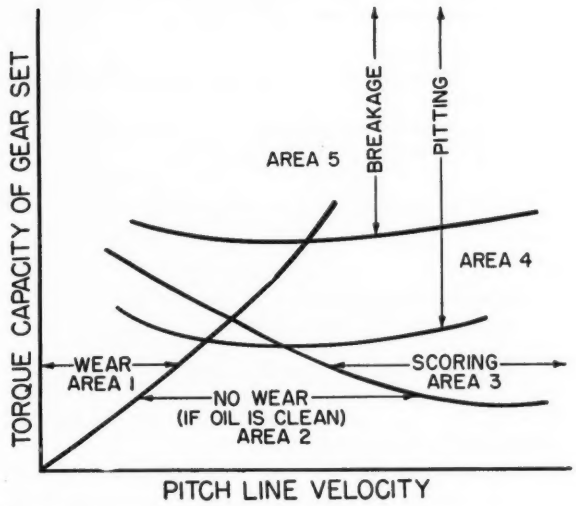


Figure 1. Areas of gear failures.

and dynamic load effects cause the gears to pit prematurely. The improved results, as shown in Figure 2, bear out this type of reasoning. The new lubricant prevented wear and scoring, thus allowing the pitting to take place in a normal manner. The end result was a much improved S-N curve, or as stated previously, the same type of test gears were able to carry approximately twice the previous load.

The top curve in Figure 2 shows a gain in load-carrying capacity of geometrically similar test gears due to improvements made in manufacture and heat treatments, when run with the improved type of lubricant. Thus, by a combination of improved lubricant and improved manufacturing techniques, the load-carrying capacity was increased from 250 K-Factor to 1,000 K-Factor.

If, however, the load is increased high enough, even the new lubricant will break down. This forms a new ceiling above which satisfactory operation is not possible until a new "fix" has been found, at which time a new cycle has been started. Again, one of the logical places to look for improvements would be in a new or improved lubricant.

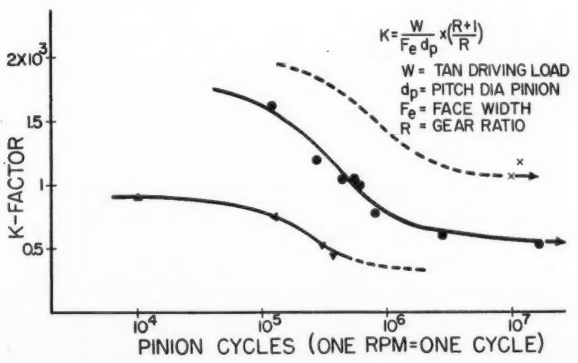


Figure 2. Pinion failures due to surface pitting.

SCORING

Assuming that tooth breakage and pitting are of a fatigue nature and, as such, are not directly related to the lubricant involved, our efforts can now be directed to failures related to lubrication, namely, wear and scoring.

We know from experience that, if a gear box is operating satisfactorily under a given set of conditions, a certain heat level is attained on the tooth surface. Since the gears are operating satisfactorily, this heat level is safe. There is a higher heat level that will break down the oil film resulting in metal-to-metal contact and ultimate gear failure. From a safe operating level, a scoring failure can be produced by putting more heat into the system. This can be accomplished by increasing the inlet oil temperature, increasing the speed of operation, and increasing the load on the gear set. This type of failure can be demonstrated by anyone who has an appropriate gear test facility and by judiciously choosing the satisfactory operating conditions.

Scoring has been defined as a combination of two distinct activities; first, the failure of the oil film in the contact area, and second, metal-to-metal contact producing a welding and tearing action resulting from this metallic contact which removes metal rapidly and continuously as long as the loads, speeds and oil temperature remain at the same level (3).

Scoring at best is rather a complicated phenomenon and the factors which affect the final scoring resistance of a gear set are as follows: tooth surface pressure, properties of the material, surface finish, surface treatment, surface velocities, temperature of the oil bath, viscosity of the oil, and the composition of the oil.

Most gear designers will agree that a method of determining the scoring resistance of a set of gears with a given oil is necessary. However, there is no generally accepted procedure to follow. Two methods which have experienced popularity are the "PVT" formula (4) and the "Temperature Flash" equation [3].

In the work carried out by the author to evaluate the lubrication phenomenon, a large amount of testing was done on lubricants and gears in terms of "PVT" and "Temperature Flash." The author's conclusions are that the "Temperature Flash" method is a better general-purpose formula for evaluating a gear design or a gear oil, and the "PVT" method does not take into consideration enough of the variables that affect the overall scoring picture.

Undoubtedly, the "PVT" formula could be used to advantage in certain phases of the gear field, particularly where the gear engineer has additional information or past experience on which to base his ultimate decision as to the ability of the oil or gears to withstand scoring.

Frequently, 1,500,000 has been used as a calculated "PVT" design limit. Figure 3 shows some "PVT" values calculated from published scoring tests (5). A larger percentage of the scoring failures occurred at calculated "PVT" values in excess of the 1,500,000 limit. Some data obtained from a British paper is plotted in Figure 4. These tests failed at much higher "PVT" values than the limit allows (6).

In addition to the above information, tests run by the author showed similar results. Under certain con-

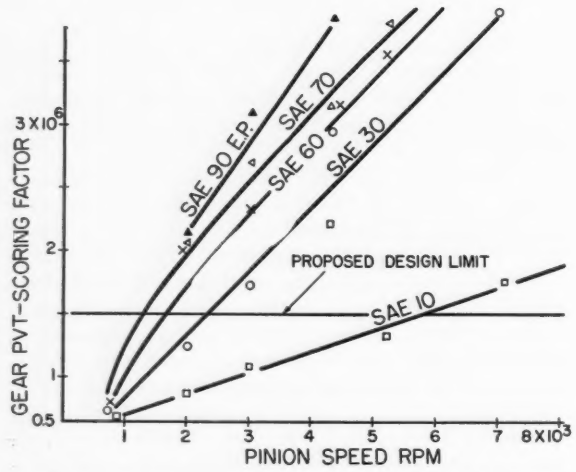


Figure 3. Scoring test 17 to 19 ratio gears using PVT method.

ditions, operation was satisfactory at "PVT" values far in excess of the 1,500,000 limit, whereas, at low speeds, even the 1,500,000 limit did not assure safe operation.

Additional information relating to the "PVT" formula can be found in reference (4).

The "Temperature Flash" method of calculating a scoring limit was proposed by Bruce Kelley (3). His method was based on theoretical work done by H. Blok (7) and takes into consideration most of the variables that affect the scoring resistance of a gear unit. Although Kelley's equation is empirical in nature, it seems to predict scoring failures with a remarkable degree of repeatibility.

The Kelley equation is as follows:

$$T_f = \left[t_i + 0.00317\, W_n \frac{\sqrt{V_1} - \sqrt{V_2}}{\sqrt{B_c/2}} \right] \frac{55}{55\text{-}S} \qquad [1]$$

where T_f = surface temperature in area of contact between the gear teeth, °F (Temperature Flash)

t_i = blank temperature of the gear, which, in most cases, is equal to the bulk oil temperature, °F

W_n = normal load per inch of contacting face width, lb/in.

V_1, V_2 = surface velocity at point on profile of tooth being examined, fps

B_c = width of band of contact, in.

S = surface finish after initial run, micro-in. rms

0.00317 = a product of the thermal constant of the gear material and the instantaneous coefficient of friction.

Equation [1] can be rewritten for application to gear teeth, as follows:

$$T_f = \left[t_i + \frac{C_t f W_t (V_1 - V_2)}{\cos\theta_t F_e (\sqrt{V_1} + \sqrt{V_2}) \sqrt{B_c/2}} \right] \frac{55}{55\text{-}S} \qquad [2]$$

where: $\dfrac{W_t}{\cos\theta_t F_e} = W_n$

θ_t = transverse pressure angle, degrees

F_e = effective face width, inches

C_t = a thermal constant of the gear material (.0528 for steel)

f = instantaneous coefficient of friction in the zone of contact (assumed to be 0.06)

$$B_c = 0.000554 \sqrt{\frac{rR}{r+R} \frac{W_t}{\cos\theta_t F_e}} \qquad [3]$$

for steel where

r = radius of curvature of pinion, inches

R = radius of curvature of gear, inches

Theoretically, the quantity T_f at failure is a constant for any given oil. In effect a plot of T_f vs pitch line velocity for any number of gear scoring failures should yield a straight line.

Figure 5 shows the results of many scoring tests performed in the author's laboratory. For any given oil, such as oil A, the calculated failure temperature T_f falls within a rather narrow band, indicating that the theory behind Equation [2] seems to stand up under test analysis.

The curves shown in Figure 6 are the same information shown in Figure 3, only calculated using the Kelley "Temperature Flash" method. A straight line for each oil seems to fit this data exceptionally well. In addition to this, it is only reasonable that the various SAE grades of oil should show up as indicated by Figure 6. For example, SAE 70 will have more scoring resistance than SAE 10.

The Kelley formula is not the final word on scoring, but it is a useful tool and about the only real check that can be given an oil for practical design purposes. Equation [2] has some limitations since it was developed for

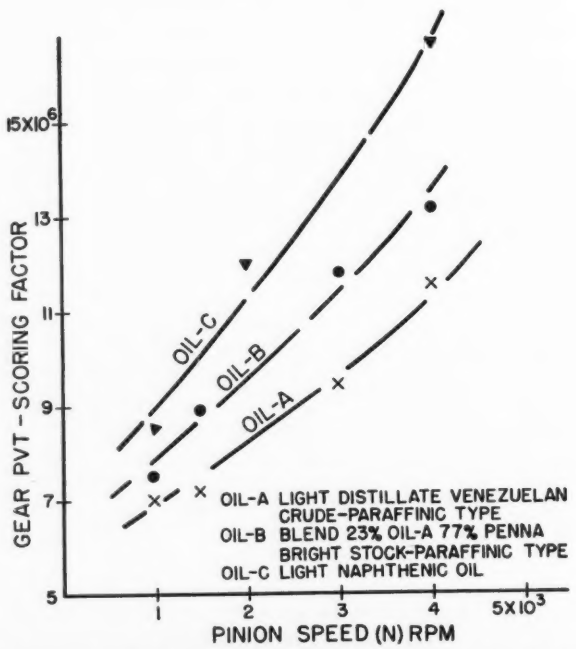


Figure 4. Scoring test 15 to 16 ratio gears using PVT method.

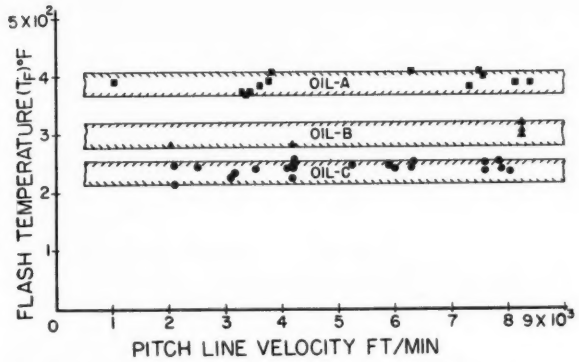


Figure 5. Scoring test results using Kelley's formula.

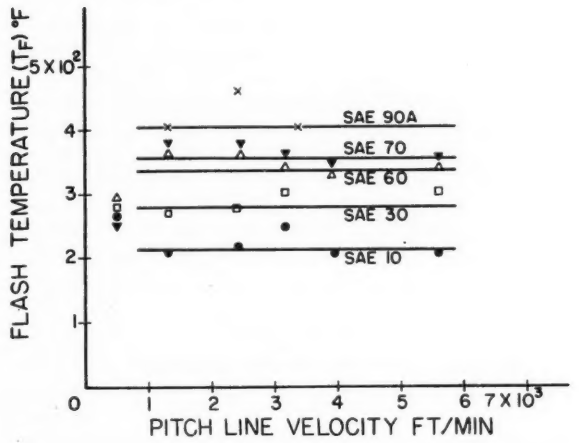


Figure 6. Scoring test results 17 to 19 ratio gears using Kelley's formula.

spur gears of the case carburized variety and for surface finishes below 55 rms. As yet, no formula has been proposed for helical or bevel gears, although recent tests show that helical gears of equivalent hardness react in a similar manner to spur gears. There are also indications that various materials and heat treatments may influence the scoring resistance of a given gear design to a limited extent. Some oils also react differently at various temperatures and may influence the results as predicted by the Kelley equation.

One major item that must be kept in mind pertaining to the "Temperature Flash" method of determining the critical temperature of a given oil is that a scoring test must be run on some sort of test apparatus in order to determine this critical temperature of the oil. Once this has been satisfactorily obtained, then this information can be applied to design practice.

To evaluate a new gear oil is rather a time consuming and costly project. The procedure may vary somewhat, depending upon the ultimate use of the oil, but, in general, the following steps should be taken: All available information pertaining to the oil should be obtained from the manufacturer and the various laboratories that have been working with the oil. Laboratory checks should be made on an oil sample, such as viscosity, pour point, flash point, and oxidation stability. Comparison tests should be run on a 4-ball wear tester and the Timken wear tester. Lubricated compression roll tests should be run under simulated service condition and the results compared with previous tests. Scoring tests using test gears on a 4-square gear testing apparatus must be run to determine the critical "Temperature Flash" (T_f) of the oil. If a radioactive gear tester is available then wear test should be run on the oil to determine its wear characteristics.

To be assured that an accurate reading on the "Temperature Flash" has been obtained for a given lubricant, several scoring tests may be made. The first scoring test should be made under conditions similar to tests made on previous oils to assure a good common ground for comparisons. The second test should be run under temperature conditions similar in nature to the service conditions of the oil. A third test should be run varying speed, load and temperature as much as possible from the conditions of tests 1 and 2, as a check on the Kelley formula for scoring. The three tests as outlined should all calculate a "Temperature Flash" (T_f) constant which when plotted vs pitch line velocity should fall on a straight line.

WEAR

Wear is a very important phenomenon, particularly in high speed gearing that must be in operation for an unlimited length of time. Wear has been defined from a gear engineer's point of view as that kind of tooth damage whereby layers of metal have been more or less uniformly removed from the surface. The three most common causes of gear tooth wear are, metal-to-metal contact due to an inadequate oil film, abrasive particles in the oil supply, and chemical wear due to the composition of the oil and its additives.

Wear, unlike scoring, is generally very hard to detect. It may be present from the very start of operation, but the rate of wear may be so slow that many millions of cycles of operation are required before any measurable amount is worn from the tooth surfaces.

Gear tests have been run for several months, accumulating millions of cycles, with little or no measurable wear. This method of testing gears for wear investigations proved undesirable since answers obtained were not conclusive and the time necessarily limited the amount of work which could be accomplished.

The radioactive technique has been adapted for testing gears since it held promise as a method of studying the wear phenomenon. The theory behind this technique indicates that wear rates can be established for various oils. Very minute quantities of wear can be readily detected in a short length of time, and several oils can be tested with the same set of test gears. Additional information can be determined by taking radiographs of metal transfer on the non-active gear teeth and the exact scoring conditions of the test gears can be pinpointed by careful observation of the change in wear rates.

The technique of using a radioactive pinion for wear testing is actually quite simple. The pinion to be tested is machined in the usual manner. The pinion is then sent to the nearest atomic pile where it is irradiated with neutrons. This makes the pinion radioactive. The gear

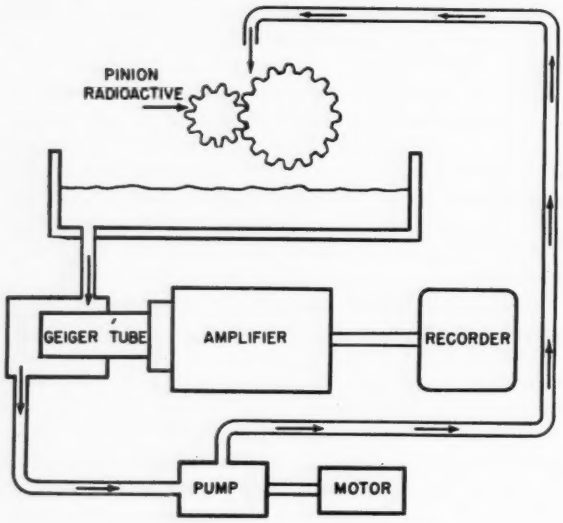


Figure 7. Radioactive gear test apparatus.

is then mounted in a test stand. The lubricant is circulated through the gear box, past a geiger tube and back into the sump, as shown in Figure 7.

When the active pinions commence to wear, the lubricating oil transports the removed iron particles past the geiger tube, where they are detected. It is a rather simple laboratory technique to convert the counting rates as recorded from the geiger tube to milligrams of wear per unit of time.

In tests run by the author, wear rates have been determined for various gear oils and in addition, some very interesting results have been uncovered in terms of when and how material is removed from a gear tooth surface. Figure 8 shows a plot of the wear in milligrams of continuous operation of a set of test gears. The object of this test was to determine under what conditions the pinion would begin to wear. The load was kept constant at 1400 K-Factor, while the speed and inlet oil

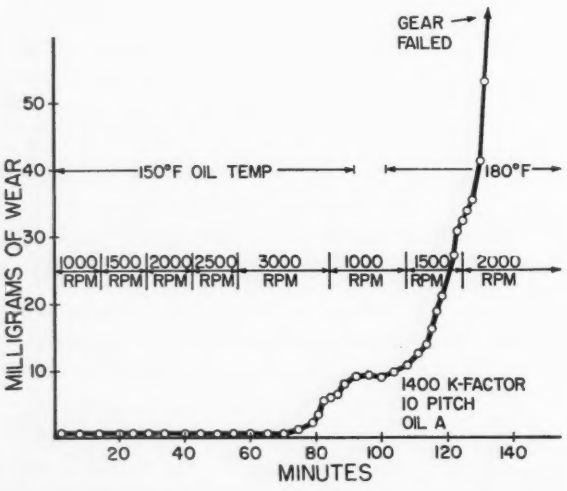


Figure 8. Radioactive gear test constant load—300° F.

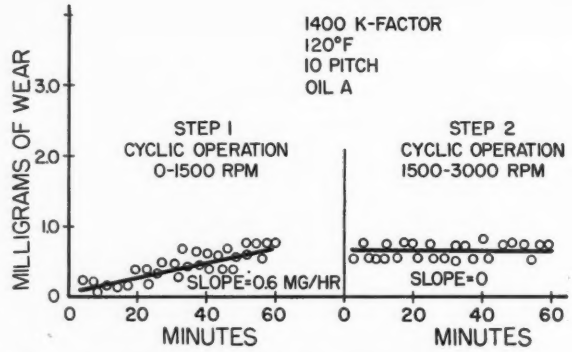


Figure 9. Radioactive gear test constant load—cyclic operation 120° F.

temperature were varied in order to produce some sort of wear. For the first 90 minutes, the temperature was kept constant at 150°F while the speed was increased in intervals of 500 rpm. At 3,000 rpm, some particles were being removed from the pinion. The rpm speed was dropped back to 1,000 rpm, thus causing the wear rate to level out. This removal of metal was undoubtedly due to some initial scoring. After 100 minutes of operation, the temperature was increased to 180°F, while the speed was kept constant at 1,000 rpm. Again, the rate of metal removal started to climb. When the speed was increased to 1,500 rpm, the rate took another definite upswing. To hasten the process, the speed was increased to 2,000 rpm, at which time the rate of wear was so great that the pinion immediately failed from destructive scoring.

Figure 9 shows the results of another radioactive test. During this test, the load was kept constant, as well as the temperature. In Step 1, the speed was varied from 0 to 1,500 rpm, and back to 0 again in approximately two minute intervals. Each point on the curve represents the wear obtained during each cycle. In Step 2, the speed was varied from 1,500 rpm to 3,000 rpm, and back to 1,500 rpm in two-minute intervals. The slope of the curve in Step 1 indicates that the cyclic operation was

(Cont. on p. 191)

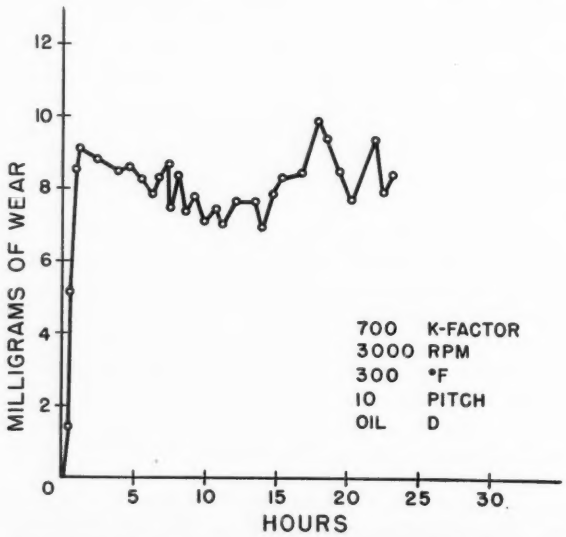


Figure 10. Radioactive gear test constant load 300° F., erratic wear.

Design and Operation of Ball Bearings for use in Pressurized-Water Reactor Systems

Phillip R. Eklund, Bettis Plant, Westinghouse Electric Co., Pittsburgh, Pa.

INTRODUCTION

In 1949, when the nuclear reactor development program began, the only technical data available on the performance of ball bearings were specifically identified with oil-lubricated service. Early in the program, it was clearly demonstrated that commercial ball-bearing materials and designs were not acceptable for service in high-temperature, high purity, pressurized-water environment. Commercial bearings seized, galled, and wore severely even under small fractions of their rated load for lubricated service. Commercial materials corroded badly and had to be abandoned.

Consequently, a program of bearing development was undertaken whereby materials were screened for wear resistance and corrosion resistance in the reactor environment. Internal features of bearings were studied, so that torques could be reduced and wear could be limited to reasonable values.

As a first approach, bearings of commercial design were fabricated from materials that passed the screening tests for wear and corrosion properties. The results of tests on these bearings were not encouraging. It became readily apparent that basic bearing design would have to be altered if the required improvements were ever to be realized. This discussion will deal primarily with experiences encountered in the design approach to ball bearings functionally adequate for use in the primary system of a pressurized-water power reactor.

BEARING APPLICATIONS

The type of equipment for which improved ball bearings were required is typified by the control rod mechanism shown in Figure 1. The mechanism serves to position a control rod in the core of a water-moderated, pressurized-water reactor. Depending on the particular design in question, different combinations of radial and thrust ball bearings are required.

In all cases the internal elements of the control rod mechanism, including the bearings, operate in system water and are exposed to the full 2000 psi system pressure at temperatures of 200-500°F.

In comparison with general oil-lubricated ball-bearing practice, the loads and speeds encountered in pressurized water reactor applications are low. Loads on main thrust bearings have been about 150 to 250 pounds. The normal speed of rotation is 11 rpm, although, under emergency conditions speeds up to 40 rpm may be encountered. Because of the low loads and speeds the difficulties that were encountered in the early phases of the ball-bearing program could not be traced to any of the classical "failure" conditions that occur in oil-lubricated bearing practice, such as spalling of the balls or ball grooves as a result of fatigue.

Ball bearings developed for control rod drive mechanism application and operated under thrust load have as criteria for performance or "failure":

1. Maximum or peak torque allowable
2. Radial play increase due to wear
3. Ability to take shock or impact loading and still operate satisfactorily.
4. Ability of the bearing materials to resist corrosion and/or wear thus lessening contamination of the water system.

During operation the total torque output of a mechanism drive motor is in the range of 8 to 10 foot-pounds. Since bearing operating speeds in mechanisms are low, it is probable that the inertia effect in the system is so slight that inertia can not be depended on to carry rotational motion over any peak torque that might develop. Thus, it is necessary that the total mechanism torque be safely less than the output of the drive motor.

Wear as manifested by an excessive increase in ball bearing radial play (1)[1] can seriously affect mechanism performance. If the mechanical and electrical system are to operate effectively, it is highly essential that the air gap between the rotor segments and stator be held within certain tolerances throughout the operating life. Reduced wear is also necessary to minimize the amount of dirt and crud (5) in the reactor primary system. As yet, the effect of wear on torque has not been successfully investigated.

Shock stability is an obvious necessity for bearings intended for shipboard operation. To evaluate the effect of shock, bearings are assembled in complete mechanisms and tested in a shock stand.

Corrosion in general is of paramount importance, since the presence of radioactivity in the primary system

[1]Numbers in parenthesis refer to glossary at end of paper.

requires a high degree of water purity and the absence or minimizing of contaminating product. Corrosion and wear products should be of such a nature as not to affect plant operation.

The water media are very aggressive with respect to corrosive attack, and materials that are ordinarily rated as highly corrosion resistant must be studied carefully for each application; in many cases they are unacceptable.

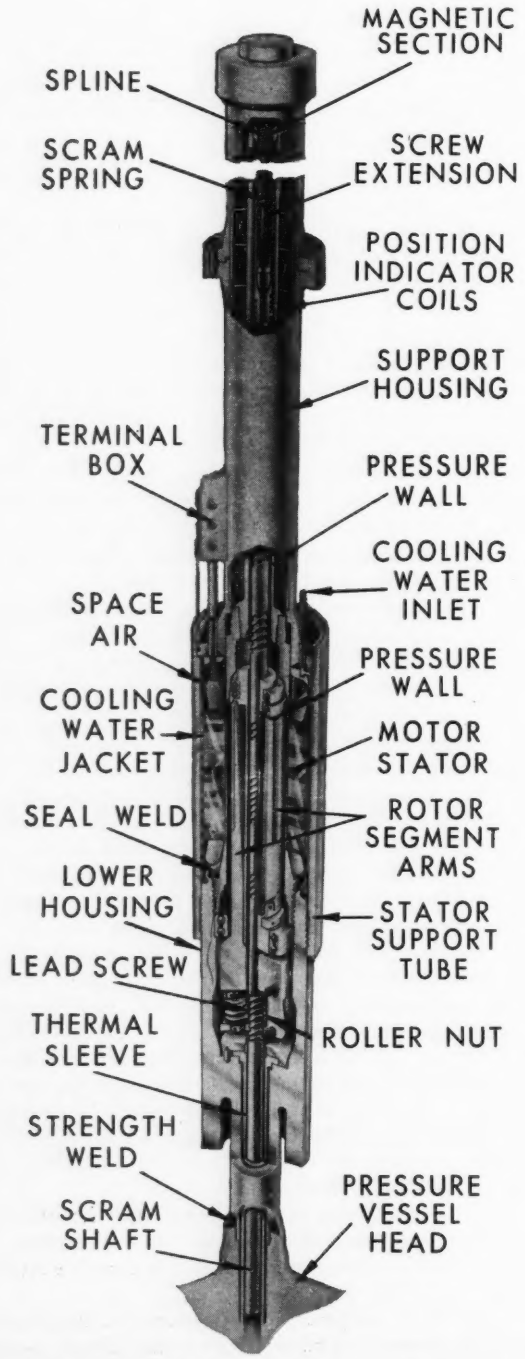


Figure 1. Control rod drive mechanism for pressurized water application.

The accumulation of corrosion and wear products in a mechanism may be one of the contributing factors to the mechanism torques that develop in service.

In order to raise overall bearing performance to the desired level, various design changes were made and different materials evaluated.

The effects of changing design and materials were determined experimentally in test rigs.

BEARING TESTING

It is not intended to describe testing procedures fully but only to indicate briefly the method of testing.

In general, ball bearing designs are tested before being fully accepted for control mechanism application. Tests are normally run in 200 to 500°F water pressurized in the 1000 to 2000 psi range. The purity of the water is controlled so that the specific resistance is at least 500,000 ohm-cm. Although the water is normally maintained at pH 6 to 8, high pH tests have been conducted with either NH_3 (pH 6.5 to 9.5) or LiOH (pH 9.0 to 10.5) as the additive. The most severe testing has been performed in oxygenated water having an oxygen content as high as 30cc per liter of water at standard temperature and pressure. Figs. 2 and 3 show schematic arrangements for radial and thrust bearing test rigs in which the wear and torque characteristics of the test bearings may be studied.

BEARING DESIGN

Early in the program, it was clearly demonstrated that commercial ball bearing materials and designs were

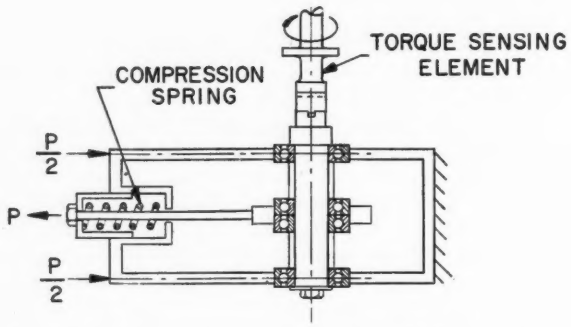


Figure 2. Schematic arrangement of radial load rig.

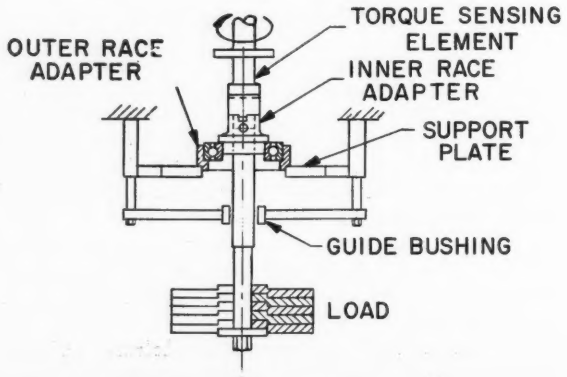


Figure 3. Schematic of thrust test rig.

not acceptable in the pressurized water environment. A considerable amount of laboratory testing was performed on suggested bearing designs. The results of initial tests were anything but encouraging. Peak torques as high as 25 foot-pounds were common. A typical torque record from laboratory tests is shown in Figure 4. Although the peaks can not be explained fully, it appears that a bearing which should show low peak torques under similar conditions of operation should be satisfactory for mechanism application.

Tests and operating experience on the present improved bearing designs generally show peak torques of the order of 3 to 4 foot-pounds over their scheduled test periods of 200,000 to 1,250,000 revolutions. In general, the average running torques seldom exceed 2 inch-pounds.

This marked improvement was brought about through changes in bearing design and proper choice of materials.

As a result of test laboratory experience, it was decided to design for an increased radial looseness.

All bearings intended for operation in high temperature pressurized water are designed "loose" by commercial standards. Initial radial play and axial play (2) are relatively great so that the large contact angles will induce low contact stresses. The present thrust bearings have an initial radial play of 0.003 to 0.004 inches. The increased radial play is also beneficial as the permissible amount of misalignment is also increased. Misalignment as used here is a measure of deviation from true perpendicularity between the bearing bore and normally horizontal faces. All thrust bearing designs are based upon the ability to operate successfully under a maximum misalignment of 0.001 inches deviation per inch of bearing race diameter.

The increase in radial clearance must, of course, be a compromise between advantage to the bearing and possible disadvantage to other components of the mechanism.

Experience gained from tests, coupled with theoretical analysis, indicated that increased race conformities (3) and high contact angles (4) tend to improve the performance of thrust bearings made from cobalt-base alloys. These thrust bearings vary in size from 116 to 120 and are equivalent to the commercial light series. Present thrust bearing designs have 53 percent conformity on the inner race and 56 percent conformity on the outer race. In these bearings the classical Hertz (contact) stresses at the inner race nearly balance those at the outer race, although the outer race contact stresses are slightly higher.

The size 111 radially-loaded bearings that are presently being used have conformities of 52 percent

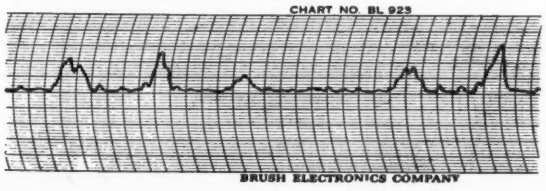
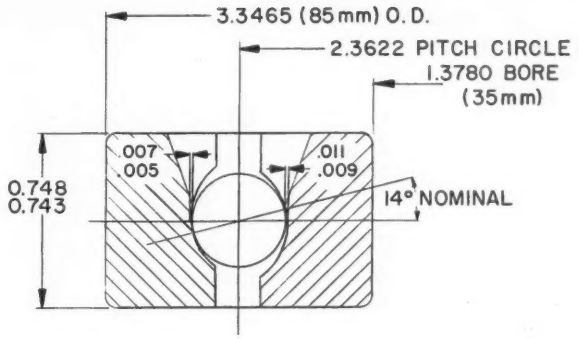


Figure 4. Typical torque record (showing 9.2 ft. lb. maximum).



0.002 IN. NOMINAL RADIAL PLAY
52% RACE CONFORMITY
11 BALLS - 5/8 DIA.
SHOULDER HEIGHT:
19% INNER RACE
17% OUTER RACE

Figure 5. 207/209 cageless thrust bearing design.

on the inner race and 54 percent on the outer race. These bearings have a radial play of approximately 0.001 inches. A slight increase in conformity and radial play over that in a standard commercial bearing also has advantage for radially-loaded bearings.

In the early phase of the ball-bearing test program it was felt that the ball retainer, or separater, contributed to the peak torques being experienced at that time. Although this postulate could not be confirmed on the basis of test results, later work resulted in a retainer design that laboratory investigation showed to have no adverse effect on bearing performance.

In general it has been found that for thrust-loaded ball bearings, the retainer pocket diameter should be 20 percent greater than the ball diameter. The total radial clearance between the I.D. of the retainer and the bearing inner race shoulder should be from 0.030 to 0.040 inches. The clearance between the retainer outside diameter and the inside diameter of the outer race should be from 2 to 3 times the inner race shoulder clearance. This gives a relatively loose assembly, but it does appear to avoid binding on the inner race and allows freedom of ball motion.

The thrust bearing design shown in Figure 5 does not utilize a retainer. It is a filler-notch type bearing which is orientated so that the dam height on the inner race is greater than that for the outer race. The notch is on the top side of the bearing. No more than 1/3 of the ball contact area overlaps the filler notch.

During design acceptance and production testing of early mechanisms the importance of various factors such as ball size variation and groove parallelism came to be more fully appreciated. A maximum permissible ball diameter variation of $\pm$ 0.000010 inches was then established for all balls in a single bearing. Annular Bearing Engineers Committee (ABEC) Class 5 tolerances were adopted for inner race groove parallelism and shoulder squareness.

For the materials used in present bearing designs, use of standard shaft and housing fits resulted in the cracking of several bearing races when they were being fitted to the shafts. Fits in use at the present avoid any "interference" to prevent the cracking of bearing races made from porous cobalt base alloys and the seizure that is characteristic of the stainless steels.

The effect of bearing design on shock was investigated to ascertain the effect of a brinelled raceway on bearing performance. A size 117 clad-bearing that had previously been subjected to a standard mechanism shock test was run for 200,000 revolutions at 26 rpm. This bearing showed excellent characteristics with the peaks no higher than 2.2 foot-pounds and the running torque was in the 2 to 3 inch-pound range. The most likely explanation for this performance is that due to the elastic deformation of the component parts, the most severe brinelling in the ball races occurs at a much lower point in the ball groove than where the balls operate under normal load. Consequently, it is felt that within certain limits shock as such should not have a serious effect upon ball bearings operating under thrust load. Table I lists the characteristics of ball bearings presently used in several mechanisms. The details of a size 116 bearing are shown in Figure 6. Figure 7 illustrates the design details of a double-row type bearing, size 118D. A double row bearing was considered in order to combine the advantages of a high contact angle, 45° in this case, and radial play of the order of 0.003 inches. However, cost and other factors detract from this design. Figure 8 illustrates an attempt to combine into a single-row bearing all the advantages of a high contact angle and a suitable radial play. In this non-circular groove design the axial play is independent of radical play and contact angle.

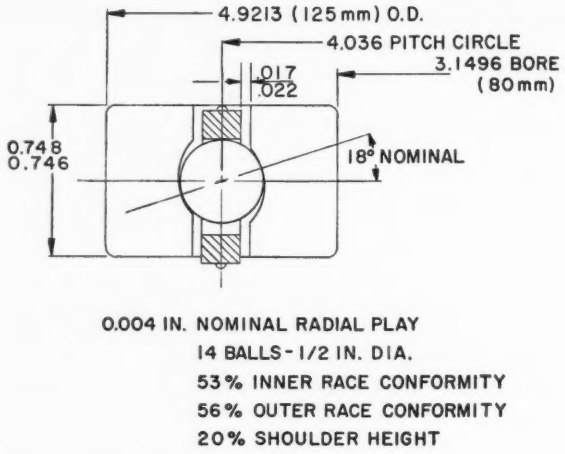


Figure 6. Size 116 bearing design.

MATERIALS

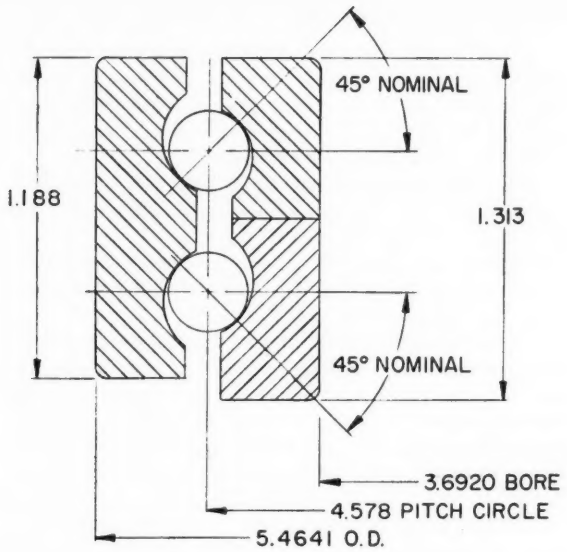
The prime requirement for any material used in the reactor primary system is that it be corrosion resistant under conditions in which it is expected to operate. After having passed screening tests for corrosion resistance, bearing materials are evaluated on the basis of wear resistance, hardness, galling and seizing characteristics, and chemical composition. This restriction narrows the field down to the use of the cobalt-base alloys and a few of the stainless steels among the bearing materials. Tungsten carbides, although desirable because of their high hardness, are not acceptable because the cobalt binder leaches out in high-temperature oxygenated water. The chromium carbides show some promise but they require further investigation. Although type 440C stainless steel is used in the food machinery and other industries, it has proved somewhat marginal in our test applications. However, when the standard 440C stainless is subjected to a chromizing process which produces an integral chrome-rich surface, some promise is indicated. Chromized 440C stainless shows excellent corrosion resistance in the various high-purity water media. The enriched surface, which actually becomes a part of the base material, has a hardness of approximately 66 to 68 Rockwell C. With the base material treated to a hardness of approximately 58 Rockwell C or more this combination shows future promise for the most severe applications. Tests are presently underway to determine the optimum combination of hardness for the chromized surface and the base material.

A modified type 440C stainless steel has shown excellent results in our standard corrosion tests. This material is modified by increasing the molybdenum con-

TABLE 1. BEARING CHARACTERISTICS

Bearing	Material			Initial Play		Contact Angle	Conformity
	Races	Balls	Retainers	Radial	Axial	Degree	%
Thrust 209	3	3	F.N.	0.0006	0.005	10	52
Rad. & Thr. 206	3	3	17-4 PH	0.0003	0.006	9	52
Radial 203	3	3	17-4 PH	0.0003	0.003		52
Radial 200	3	3	17-4 PH	0.0002	0.002		52
Thrust 207-209	25	25	F.N.	0.002	0.015	14	52
Rad. & Thr. 206	25	25	17-4 PH	0.0018	0.013	20	52
Radial 203	25	25		0.0009	0.006		52
Cam Latch 202	25	25		0.001	0.008		52
Thrust 116	25	25	17-4 PH	0.004	0.026	17.7	52.7/55.7
Radial 109	25	25	F.N.	0.001	0.008		52
Thrust 118D	25	3	D.R.	0.003	0.004	45	53/56
Synchr. 110S	25	3	F.N.	0.001	0.008		52½
Radial 110X	25	3	F.N.		0.008		52½

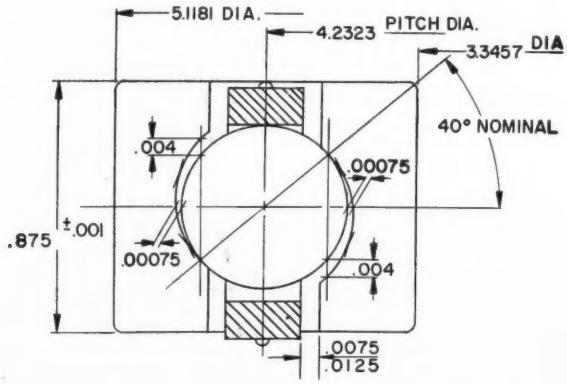
D.R. = Double Row
F.N. = Filler Notch



NOMINAL RADIAL PLAY ----- 0.003 IN.
NOMINAL AXIAL PLAY ----- 0.003 IN.
CONFORMITY:
OUTER RACE ------- 56 %
INNER RACE ------- 53 %
LOAD SHOULDER HEIGHT:
OUTER RACE ------- 32 %
INNER RACE ------- 30 %
BALL DIAMETER - 1/2 IN. -- 27 PER ROW

Figure 7. Size 118-D (double row) thrust bearing design.

tent to 4 percent instead of the 0.75 percent with which type 440C is normally supplied. This material is being



NOMINAL RADIAL PLAY ------ 0.003 IN.
NOMINAL AXIAL PLAY ------ 0.008 IN.
CONFORMITY AT BALL-RACE CONTACTS
OUTER RACE ------ 56 %
INNER RACE ------ 53 %
LOAD SHOULDER HEIGHT
OUTER AND INNER RACE -- 22%
14 BALLS 1/2 IN. DIA.

Figure 8. Non-circular groove design.

used in high-temperature bearing applications. The increased molybdenum content increases the hot hardness; furthermore, it is also known that increasing the molybdenum content enhances the wear properties of the materials. This material shows promise for certain bearing applications.

Of all the materials considered, the most satisfactory race material for non shock application is the cast No. 19 cobalt-base alloy. The No. 19 castings are machined and finished in the as-received condition, no further heat treatment is required.

For shock application the wrought No. 25 alloy is preferred.

Because of its nature, a considerable amount of processing and cold working is required to make the No. 25 alloy suitable for ball bearing applications. This material is obtained in the form of wrought alloy bar, machined to blank size, and then cold reduced in a single squeeze operation to 65 percent of its original height. Some difficulties due to cracking were experienced in the first attempts to work large pieces of No. 25 alloy. However, the difficulties were resolved and the material does have excellent impact resistance and from a shock standpoint it is satisfactory.

An alternate bearing design shown in Fig. 9 is an attempt to eliminate the high cost of the No. 25 alloy and the additional high cost of processing and machining attendant with the use of this material. The hard facing shown in Fig. 9 consists of a 1/16 in. thick layer of No. 1 or No. 63 alloy deposited by acetylene torch in the ball groove area of the ball bearing rings. The base material in this case is type 304 stainless steel. This combination has shown satisfactory results for non shock applications. The base material, however, appears to be too soft to sustain any excessive loading under impact. The results of an impact load on a clad bearing may be seen in Fig. 10. However, by a process now under development, a hard facing can be deposited upon a type-410 stainless-steel base material. The type 410-stainless can be hardened by heat treatment to approximately 30 to 40 Rockwell C. This treatment raises the yield point and improves the support for shock or impact loading.

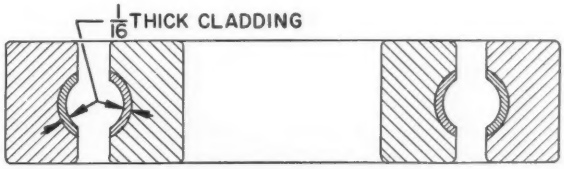


Figure 9. Finish machined ball bearing rings.

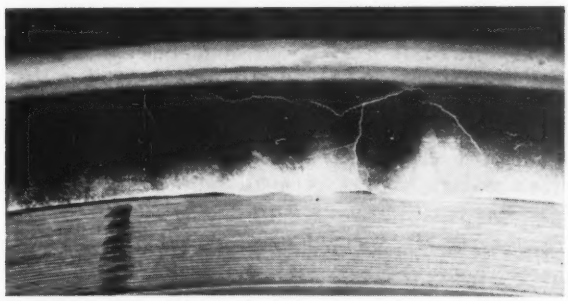


Figure 10. Effect of brinelling upon a clad bearing race.

Cast alloy No. 3 is considered best for balls in both shock and non shock applications. Fused aluminum oxide (Al_2O_3) balls were studied to determine their performance in a bearing assembly, however it developed that the fused aluminum oxide balls were soluble in high-temperature high-pressure water. They lost considerable weight in static corrosion-type tests in this environment. Consequently, for the moment at least, this material holds little promise.

Since shock is a major factor in some application the relative crushing strength of various ball materials was investigated. The results may be seen in Table 2.

TABLE 2. DETERMINATION OF CRUSHING LOAD FOR ½-INCH DIAMETER BALLS — MATERIALS AS SHOWN

Material	3	19	31	63	93	j	Al_2O_3	52100
Crushing Load-lb.	8700	11300	5300	8100	11550	8000	2900	27000

Retainers are fabricated from 17-4 PH stainless steel, rough machined, heat treated to a hardness of 40 to 45 Rockwell C, and then finish machined. The two retainer halves are held together by means of No. 10 alloy stainless steel rivets located between the ball pockets. The No. 10 alloy is used because of its excellent resistance to crevice corrosion and because it can be cold headed without introducing excessive work hardening.

Other retainer materials such as 410 stainless and 416 stainless appear to be satisfactory on the basis of test results. Table 3 shows the chemical composition of some of the various alloys which are of interest from testing and production design standpoints for the various ball-bearing components.

LUBRICATION

Tests have shown that the addition of only 0.2 percent polyalkylene glycol to the water media produces a 15 to 1 reduction in ball-bearing wear. The effect on torque is also striking.

While the effect of an additive has been demonstrated, other factors such as additive breakdown and deposition on critical heat transfer areas in the pressurized water system preclude their use at the present time.

CONCLUDING REMARKS

Tests of thrust-loaded ball bearings show that by increasing both the radial clearance and contact angle, and by designing for a more open conformity, the bearing can be made less susceptible to the effects of accumulated particles and misalignment.

A slight increase in conformity and radial play over that in a standard commercial bearing also has advantage for radially-loaded bearings.

Recent tests have shown that the crud and dirt generated within the mechanism has no appreciable effect upon bearing operation.

Because of the increased load-life demands expected for future mechanism designs, bearings with more precise operational characteristics must be developed. These bearings should have more exact and predictable operation with respect to load, life, and temperature. This will require not only additional testing, but also closer control over testing procedures.

The advances in design and experimental techniques made in connection with the development of ball bearings for pressurized-water reactor applications evolved from a hazy and uncertain beginning. Conventional bearing designs were found to be unsatisfactory for water-lubricated service, and considerable background experience was accumulated so that design changes are now made with some reasonable assurance of success.

The increased load-life demands that will be forthcoming in connection with future nuclear power plants are now viewed with greater confidence and less skepticism. The ultimate solution may come in the field of design alone, it may come in the field of metallurgy, or it may come when a lubricant is developed that will be compatible with all elements of the primary water system.

ACKNOWLEDGEMENTS

The author is especially grateful to Mr. J. W. Flaherty, of the Mechanism Development Section, who has very generously assisted in the preparation of this paper and to Mr. J. C. Eazor, Jr., engineer in charge of the laboratory; Mr. L. R. Puskaric, in charge of the laboratory assembly and test room; and to all other laboratory and test personnel who have so graciously assisted in carrying out our test program.

(Cont. on p. 192)

TABLE 3. CHEMICAL COMPOSITION OF VARIOUS BALL BEARING ALLOYS

	Approximate Chemical Composition											
Alloy	Co	Ni	Fe	Cr	Mo	W	C	Mn	Si	Others	Hardness Rc	Used For
1	46	3*	3*	31		13	2.45			1	54-57	Hard Facing
3	46	3*	3*	31		13	2.45			1	53 56	Balls
10 SS				16			0.08*				—	Rivets
19	52		3*	31		10	1.8			2	50-53	Races
25	50	10	3*	20	1*	15	0.09			12	52††	Races
31	10			23	8		4.25		2		65	Balls
63	Bal.			28		20	2.0			1 Va	58	Balls and Hard Facing
93	6		55	17	15		3.05			4	64-66†	Balls
J	41	2.5*	3*	32		17	2.5			2	58	Balls
17-4 PH		3.75		16.5			0.04			3.25 Cu	40-45†	Retainers
304 SS		9.5		19			0.08	2*	1*		—	Base for Hard facing
410 SS		0.50*		12.5			0.15*	1*	1*		30†	

* Maximum † Heat Treated ††Cold Worked and Heat Treated

Molybdenum Disulfide and Related Solid Lubricants

Bernard C. Stupp, Hohman Plating & Mfg., Inc., Dayton, Ohio

Methods for utilizing molybdenum disulfide were studied using an opposed loading on a Timken test cup with 4130 steel rub shoes and measuring coefficient of friction by means of strain gages.

These test data indicate a great variation in wear life and friction over a wide range of different types of applications. Films bonded with organic binders show good wear life and excellent friction coefficients.

In comparing molybdenum disulfide, graphite, and boron nitride, molybdenum disulfide appears to be superior when used in bonded coatings.

Wear life of organic bonded films are affected by many impurities and prolonged exposure to heat.

Bonded molybdenum disulfide films with inorganic binding media show interesting results. Inorganic films, while not developed to the stage of organic films, indicate that the art is not bound to the use of organic bonded films.

INTRODUCTION

The use of molybdenum disulfide as a solid lubricant has been referred to with increasing frequency from 1927 (1)[1] to the present date. A survey of the literature shows many suggested methods of use such as incorporation in molded plastic members, sintered metals, impregnation into cellulosic materials, inclusion with oils and greases (2), and surface bonded coatings.

Of these mentioned uses it is felt that surface bonded coatings offer the soundest engineering approach to the proper use of solid lubricants.

The ultimate benefits to be gained from the use of bonded solid lubricants depend on many factors, such as type of bonding agent, type and amount of various impurities, types of solid lubricants, surface finish or pretreatment, thickness of film and film hardness to mention a few. The effects of varying surface finish, pretreatment, film thickness and hardness will not be within the scope of this report.

The objectives of this paper are to show the effects of various types of resins on friction and wear life, the effects of the presence of impurities, and the deteroriation by heat of organic bonded films.

Inorganic bonded films can also be used and data is included comparing several types of inorganic bonded coatings.

To show the effects of these variables, many tests were conducted on friction and endurance apparatus with resin formulations and impurities as variables.

[1]Numbers in parentheses refer to references at end of paper.

Review of Physical Properties of Various Solid Lubricants

When the use of a solid lubricant is contemplated it is natural to compare the general physical properties of one solid against another.

In general, in order for a solid material to function satisfactorily as a lubricant it must have low shear strength and a strong affinity for the metal surface under the environment in which it is to be used (3, 4, 5.) There are undoubtedly other factors involved, but to date these two characteristics appear most important.

Graphite

Graphite has been used universally as a solid lubricant. It has low shear strength and some affinity for metal surfaces. Its lubricating qualities are generally attributed to absorbed gases and moisture in its laminar structure (6.)

At elevated temperatures graphite can act as a catalytic agent in reducing other solid materials and at temperatures above 1000°F oxidizes rapidly.

Cadmium Iodide

Cadmium iodide has the general characteristics required of a solid lubricant but is affected by moisture and in practice is not as satisfactory as graphite and molybdenum disulfide.

Boron Nitride

Boron nitride has the proper crystal structure to give low shear strength, but this material does not react chemically with metal surfaces. It therefore fails to give any lubricating qualities under normal conditions.

Molybdenum Disulfide

The general physical properties of molybdenum disulfide are ideally suited as a solid lubricant in that it has low shear strength and good affinity for metal surfaces. The hardness is generally given as 1 to 1.5 on the Mohs scale and presumably the hardness can be altered somewhat by changing the distance of the space lattice in the crystal structure (9.) The wettability of the dry powder can be greatly influenced by various media.

The crystals of molybdenum disulfide can be readily plated with other metals.

Under certain conditions molybdenum disulfide can induce corrosion, this, however, can be controlled. It oxidizes rapidly above 750°F.

Molybdenum disulfide does not depend on absorbed gases or liquids within its crystal structure for its

lubricity as does graphite and it has a greater affinity for most metal surfaces.

Molybdenum disulfide acts as a very good catalytic agent in many organic reactions and this property must be taken into account when using this material with binders and carriers.

With these general properties, molybdenum disulfide lends itself nicely to bonded- or surface-lubricating films.

APPARATUS AND PROCEDURE FOR EVALUATING FRICTION & ENDURANCE

When comparing various coatings in the laboratory, it is necessary to have a machine or fixture that will give comparative data. Various types of machines are in use and they all have their advantages and disadvantages.

The test machine used for all the data presented in this paper is shown diagrammatically in Figure 1 and a photograph of the equipment appears in Figure 2. Referring to Figure 1, the coated specimen is a standard Timken test cup T-54148. This test specimen is mounted on a shaft which is given rotary motion by means of a variable-speed belt drive. The wearing surfaces are 4130 steel blocks $\frac{5}{8}$ x $\frac{1}{4}$ x $\frac{1}{2}$ inch, carburized and hardened to 60 Rockwell C. The mating or wearing surfaces are ground and polished. These wear or rub shoes are mounted in pivotal holders secured to a rolling-contact bearing which is free to rotate about the same axis as the test specimen. A torque arm is extended from this free bearing, which gives the resultant friction force. Torque is measured by four strain gages mounted on internal and external surfaces of a dynamometer ring. These gages are incorporated in a Wheatstone bridge circuit so as to be self-compensating against ambient temperature changes.

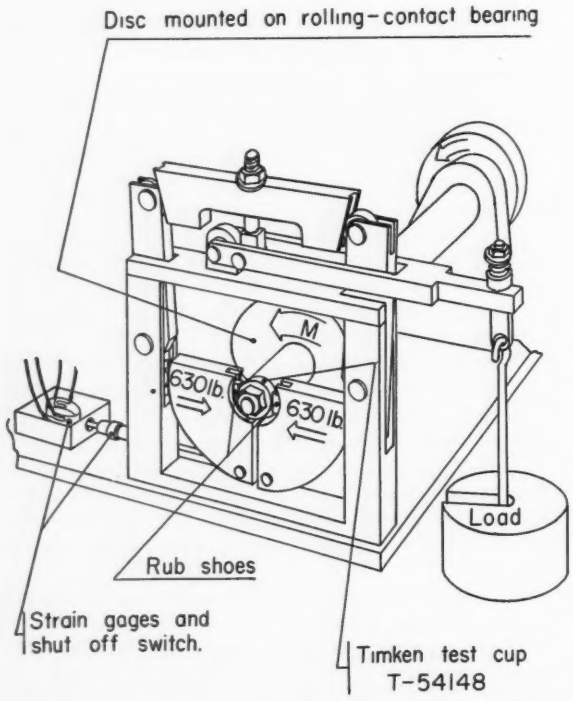


Figure 1. Diagrammatic sketch of Model A-3 friction and wear tester.

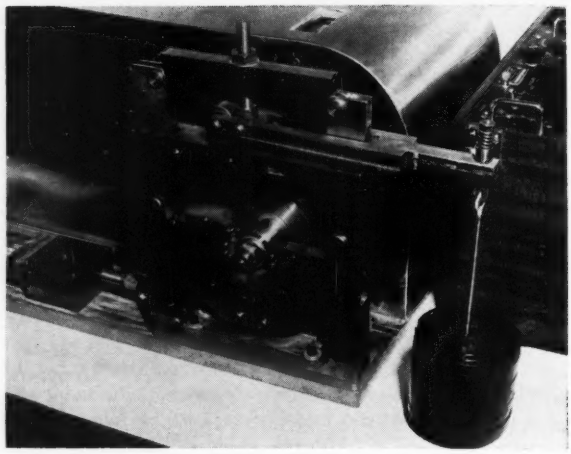


Figure 2. Model A-3 tester.

The load of 630 pounds, normally applied on each rub shoe, is obtained through a system of levers with a beam load of 14 pounds. This gives a unit loading of 86,000 psi. The multiplying ratio is 45 to 1 on each rub shoe. This load is imposed on the rub shoe through rollers which permit free rotation of the rub shoes about the same axis as the coated specimen. The rotary speed used was 72 rpm which corresponds to 25.9 feet per minute.

This particular machine was selected for the following reasons:

1. Friction readings on this machine correlate closely to reading on the radially loaded fixture as used by others (5).
2. Provides line contact at the beginning of of the test and a conforming mating surface after a short run.
3. Provides accurate friction readings without the necessity of the rub shoes moving in relation to their wear pattern.
4. Rub shoes located so as to contact the specimen on diametrically opposite sides eliminates bending moments in the shaft and results in uniform wear patterns assuring better reproducibility of tests.
5. The working area is easily encased with a cover to allow testing in various atmospheres. The working area can also be easily enclosed with an oven or kiln for elevated temperatures.
6. By doubling the rub area the work being done is doubled and the test time is considerably shorter than with a single rub shoe.

TABLE 1. Various solids bonded on a manganese phosphated surface. Rotary speed constant at 72 rpm (25.9 fpm). Thickness of coating varied from 0.0003 to 0.005 inch. All tests run at room temperature and no atmospheric control.

No.	*Basic Resin Types*	*Solid Lubricant*	*Kinetic Coef. of Friction*	*Wear Life (Cycles)*
1	Phenolic	Boron Nitride	0.148	360
2	Phenolic	Cadmium Iodide	0.088	4320
3	Phenolic	Graphite	0.080	8640
4	Phenolic	Tungsten Disulfide	0.034	100,460
5	Phenolic	Molybdenum Disulfide	0.036	103,680

VARIOUS SOLIDS AS LUBRICANTS IN BONDED FILMS

Referring to Table 1 it can be seen that for the most part molybdenum disulfide is superior to graphite, boron nitride, and cadmium iodide as a solid.

In all of these cases the pretreatment consisted of manganese phosphate. The resin binder was the same in all cases and the film thickness varied from 0.0003 to 0.0005 inch.

VARIOUS ORGANIC BONDING AGENTS

Surface films utilizing resin binders offer a convenient method of using the desirable properties of molybdenum disulfide.

Resin bonding lubricant materials are available commercially under various trade names. The data presented in this paper was collected on laboratory-control materials and none of it alludes to nor describes any of the commercial materials on the market unless by coincidence.

When using resin-bonded films, the surface to be coated is generally made clean and roughened by various means such as blasting, phosphating, etching, etc. to give a good bonding surface. These preparatory methods are old in the art of bonding and well established. The part is then coated with the lubricant film by spraying, dipping, or brushing after which it is air dried or baked depending on the type of resin binder used.

Figure 3 shows a typical friction curve plotted against the cycle time.

The type of binder used can give a very wide range of results as shown in Table 2.

Of the various resin binders evaluated, the phenolics exhibit the lower friction and longer wear life (Table 2.) This general category covers a broad field and not all phenolic resins are equally good. Generally the higher molecular weight fractions give superior results. Some of the more important factors influencing good results are as follows (11):

1. Cohesive strength decreases with the addition of plasticizers and adhesive strength increases.

2. Modulus of elasticity of the resin must be selected to give minimum creep under load, yet allowing enough flexibility to permit a certain amount of self healing.

3. Evaporation or diffusion of volatiles from the film is of some importance. If too thick a layer is sprayed when applying resin-bonded coatings a "skin" may form and prevent this necessary evaporation of solvent. An example of this can be shown by a test conducted by spraying a series of cups to a thickness of 0.0004 inch and then curing for one hour at 375°F as a control. Another series of cups were sprayed with an extremely thin coating of 0.0005 inch and cured one hour at 375°F and then repeated eight times for a total thickness of 0.0004 inch.

The control cups ran with friction of 0.037 for an average total of 106,000 cycles. The multiple coated cups ran with an average friction of 0.035 and averaged 121,000 cycles to failure. This difference, although not great indicates the necessity of removing solvent.

The techniques of multiple coatings mentioned previously need not generally be used if the resins and solvents are selected properly.

4. The pH of the metal surface to be coated is important and should be as near neutral as possible.

5. Absorbed films or gases on the metal surface should be avoided.

6. The nature of side chains in the case of polymers can be a very important factor.

7. The process of polymerization and formation of by-products should be considered.

8. The polarity of the surface being coated and that of the bonding resin can account for poor results.

9. Adequate wetting of the solid particles by the bonding media is naturally of utmost importance.

10. The catalytic effect of the solids to the resin must be considered.

As pointed out earlier, molybdenum disulfide can act as a catalyst. An example of this in Table 2 are items 4 and 7. In these cases the disulfide acts as a

TABLE 2. Various resin bonded coatings over a manganese phosphated surface. Rotary speed constant at 72 rpm (25.9 fpm). Thickness of coating varied from 0.0003 to 0.0005 inch. All tests run at room temperature and no atmospheric control.

No.	*Basic Resin Types*	*Solid Lubricant*	*Kinetic Coef. of Friction*	*Wear Life (Cycles)*
1	Phenolic	MoS_2	0.034	103,680
2	Phenolic-Flurocarbon	MoS_2	0.034	120,600
3	Phenolic—Vinyl Copolymer	MoS_2	0.040	102,660
5	Phenolic—Vinyl Acetate	MoS_2	0.040	96,120
4	Di-isocyanate—Castor Oil	MoS_2	0.060	96,750
6	Phenolic—Acyronitril	MoS_2	0.045	86,400
7	Di-isocyanate—Phenolic	MoS_2	0.050	86,400
8	Corn Syrup (8)	MoS_2	0.031	85,080
9	Phenolic—Rubber	MoS_2	0.064	69,120
10	Phenolic—Neoprene	MoS_2	0.035	68,000
11	Phenolic—Acrylic	MoS_2	0.060	50,400
12	Phenolic—Epoxy	MoS_2	0.063	36,000
13	Phenolic—Amide	MoS_2	0.074	23,760
14	Phenolic—Vinyl Butyral	MoS_2	0.065	21,600
15	Vinyl Chloride	MoS_2	0.070	21,600
16	Silicone	MoS_2	0.054	15,120

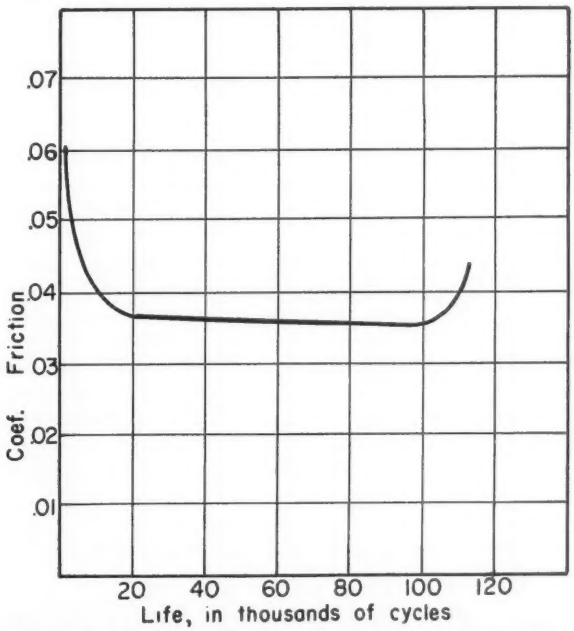


Figure 3. Typical phenolic resin bonded MoS_2 coating over manganese phosphated surface at 72 rpm (25.9 fpm). Thickness of coating .0004 in. Tests at room temperature with no atmospheric control.

TABLE 3. Effect of various additives on phenolic resin bonded MoS_2 coating over phosphated surface. Tests run at 72 rpm (25.9 fpm) at room temperature with no atmospheric control and thickness varying from .0003 to .0005 inch.

No.	*Additive*	*% to Mo S₂*	*Effect on wear life*
1	Sodium Carbonate	1	Decreases 45%
2	Potassium Carbonate	1	Decreases 42%
3	Lead Carbonate	1	Decreases 5%
4	Barium Carbonate	1	Decreases 55%
5	Calcium Carbonate	1	Decreases 12%
6	Sodium Chromate	2	Decreases 70%
7	Potassium Chromate	½	Decreases 15%
8	Ammonium Chromate	1	Decreases 2%
9	Maleic Acid	1	Decreases 4%
10	Fluoro-Carbon Wax	1	Decreases 26%
11	Cadmium Oxide	10	Decreases 15%
12	Starch	2	Decreases 40%
13	Camphor	1	Decreases 35%
14	Carnauba Wax	2	Decreases 15%
15	Saccharin	1	No change
16	Albumen (Egg)	2	Increases 5%
17	Sugar	2	Increases 8%
18	Iodine	½	Increases 15%

catalyst to the di-isocyanate and in several days is completely polymerized to a solid mass. This may have other interesting uses but certainly not as a surface bonded coating.

EFFECTS OF VARIOUS ADDITIVES TO PHENOLIC RESINS

As is to be expected, when introducing materials other than the solid lubricating material to the resin binder, the overall performance is affected and in some instances can lose all of its usefulness as a lubricating film. Examples of these effects are shown in Table 3 where all of the cases represented were run with phenolic bonded films over a manganese phosphated surface.

Table 2 may raise some questions as to why some of these materials were investigated, and it should be pointed out that in practice protective colloids are an aid in preventing settling in the liquid stage. Some of these materials, such as sugar, also help the resin wettability on the molybdenum disulfide particles.

EFFECTS OF ELEVATED TEMPERATURES ON RESIN BONDED FILMS

Organic resin-bonded coatings are naturally limited in use to temperature ranges within the limits of the resin itself (10). Since high temperatures are undoubtedly developed at the rubbing contact areas, it is reasonable to assume that this prolonged heating affects the wear life of the coating. Figure 4 shows the effects of heat on organic resin bonded coatings. In this test, the working area of the tester was covered with a heating kiln and the air temperature maintained at 300°F. for the duration of the test. The test specimens were pretreated with manganese phosphate and a phenolic resin was used. The chart compares the control specimens run at room temperature with the curve run at the elevated temperature.

Tests were also run to measure the effect of prolonged soak heating at 400°F. before testing. The results of this test are shown in Figure 5.

The cups used in this test were all manganese phosphated and all sprayed simultaneously using a phenolic resin bonded coating. After the normal cure at 375°F. for one hour, the specimens were soak-heated to 400°F. for various lengths of time as shown in Figure 5. From these data, it can be seen that prolonged heating definitely affects the cohesive strength within the resin and is at least one factor causing deterioration of the film.

INORGANIC BINDERS

Referring to Table 4, some metallic matrix type binders were evaluated on the same test equipment.

Item 6 in the table consists of a so-called diffusion process as described by McCullough (7), and is apparently of no practical significance where heavy loads are concerned.

This process consists of packing the specimens in molybdenum disulfide and heating at 500°F. for a period of four hours under pressure of 6000 psi. The coefficient of friction on this coating is low, but the wear life is exceedingly short.

Of the other coatings shown in Table 4, the metal binding matrices were formed using known methods such as evaporation, electro-deposition, and cementation of metal-coated molybdenum disulfide particles.

The inherent problem in using inorganic binders is that of getting high enough percentage of molybdenum disulfide and still retaining a cementing or bonding action. Research data indicates, however, that this can undoubtedly be overcome.

The friction coefficients of these coatings are on the average lower than the resin bonded coatings.

Although the wear lives shown in Table 4 do not indicate any particular advantages over resin coatings, it must be remembered that the relative development of the art is such that this picture will most certainly change in the near future.

Figure 6 shows a typical phenolic-resin-bonded molybdenum disulfide coating compared to an inorganic

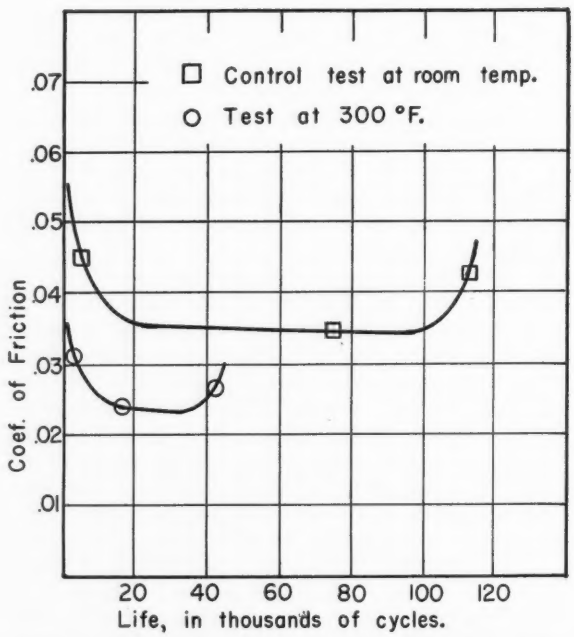


Figure 4. Typical phenolic resin bonded MoS_2 coating over manganese phosphated surface at 72 rpm (25.9 fpm). Thickness of coating .00035 in. Tests run at 300 degrees F with no atmospheric control.

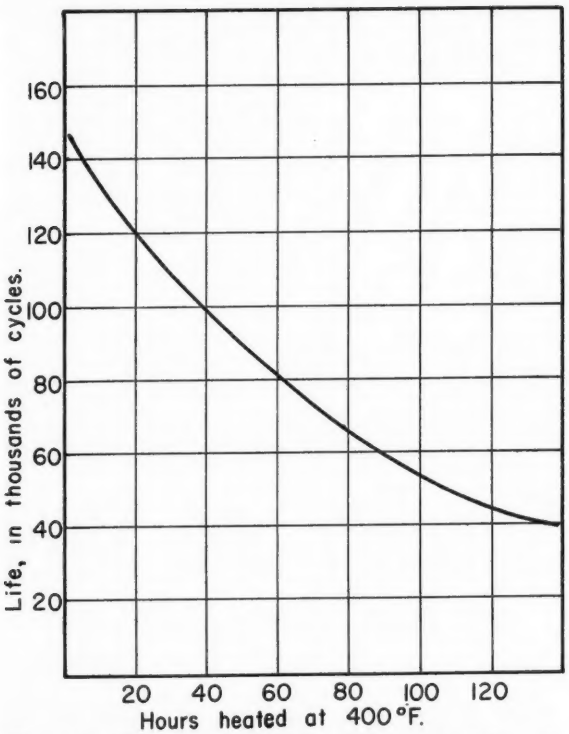


Figure 5. Effect of prolonged heating on phenolic resin bonded MoS_2 coatings over phosphated surface at 72 rpm and room temperature with no atmospheric control. Thickness of coatings varied from .0003 to .0005 in.

metal-matrix type coating at an elevated temperature of 300°F. The data in this chart shows clearly that the inorganic type coatings are superior to resin types at elevated temperatures.

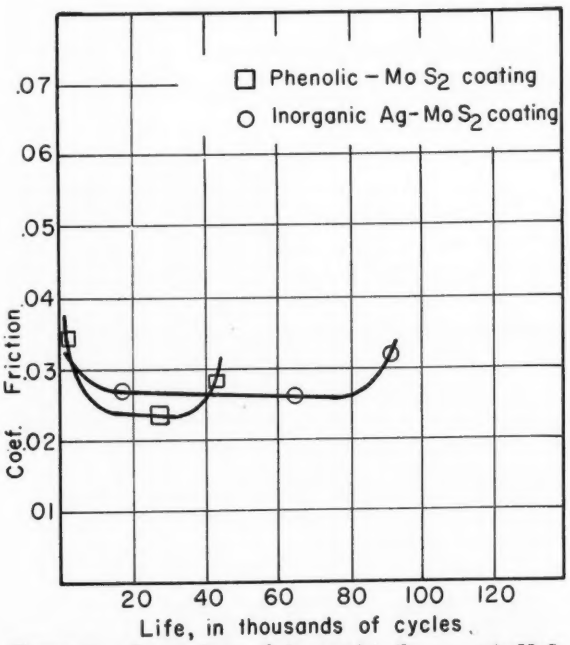


Figure 6. Comparison of inorganic silver matrix-MoS_2 coating with typical phenolic resin bonded MoS_2 coating at 72 rpm, (25.9 fpm) at 300 degrees F with no atmospheric control. Thickness of coating varied from .004 to .0008 in.

TABLE 4. Inorganic binders evaluated at 72 rpm (25.9 fpm). All tests at room temperature with no atmospheric control. Coating thickness varied from 0.0004 to 0.0008 inch.

No.	*Binder*	*Solid Lubricant*	*Kinetic Coefficient Friction*	*Wear Life (Cycles)*
1	Silver matrix	MoS_2	0.032	103,680
2	Nickel matrix	MoS_2	0.045	73,440
3	Chromium matrix	MoS_2	0.040	43,200
4	Copper matrix	MoS_2	0.036	38,880
5	Lead matrix	MoS_2	0.110	360
6	Diffusion (7)	MoS_2	0.032	850

CONCLUSIONS

Different resins and addition agents can have considerable effect on coefficient of friction and endurance life of bonded molybdenum disulfide surface coatings.

Molybdenum disulfide shows the best characteristics for surface bonded films of the various solids evaluated.

Heat changes the endurance life of resin bonded films more severely than it does metal-matrix bonded coatings.

The friction and endurance data obtained using metals as bonding agents for molybdenum disulfide have been encouraging. These results indicate that, with some further development, the inorganic metal binders will give coatings which far surpass the resin binders in endurance life as well as providing lower coefficients of friction. These binders are more stable than the resin binders and are not as adversely effected by environmental conditions such as temperature and humidity. The metallic-type binders should be more inert in the presence of liquid lubricants.

Proper techniques in application must be used in order to insure best results. Other factors not covered in this paper, such as surface pretreatment, ratio of resin to solids, shear strength of the entire coating structure and particle size of the solids are also important factors and must be considered when using solid lubricants.

The use of solid lubricants in various forms has become widespread in recent years. It is evident that many problems remain unsolved in meeting the requirements imposed on these materials. Many of these problems will most certainly be solved in the future, further advancing the use of solid lubricants.

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Treatment of Oil Waste

(Cont. from p. 147)

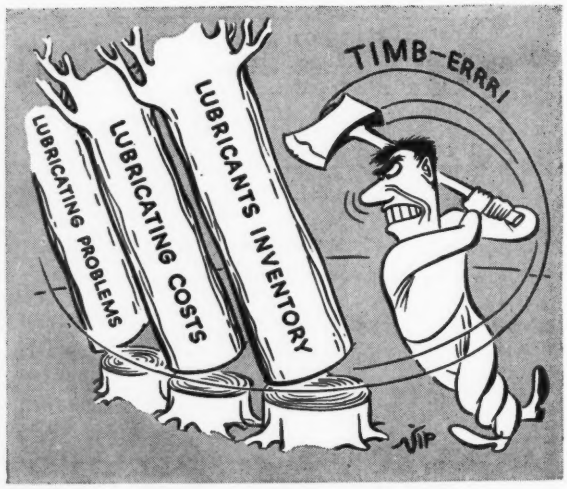
The treatment of waste oils on a batch and continuous basis can be accomplished in an integral operation. Treatment of batch discarded oil such as emulsified oils of many types can be effectively treated with calcium chloride and then combined with the continuous waste for final treatment. Satisfactory treatment of the continuous waste to meet stream requirements has been effected with ferric chloride and lime.

The facilities have proven to be adequate and the design features of the facility herein described have been incorporated into three other waste plants presently being built which will treat waste waters from machining plant having similar characteristics.

REFERENCES

(1) Winger, J. C., "Petroleum to Double in Ten Years", *Chemical and Engineering News*, pp. 5356 - 58, December 12, 1955.

(2) Eldridge, E. F. and Purdy, R. W., "Treatment and Disposal of Waste Soluble Oils", *Sewage Works Journal*, Vol. XX No. 5, pp. 849 - 56, September, 1948.



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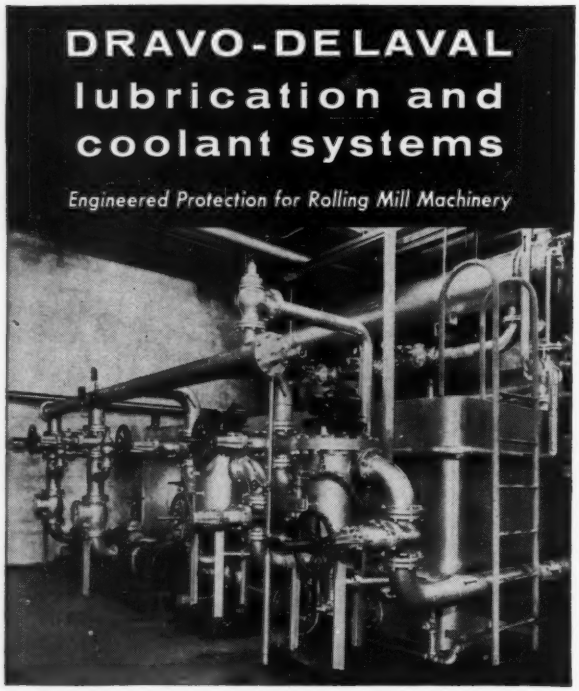

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Product Literature

TOTAL WELDING DIRECTORY

The 1958/59 edition of The Welding Directory, the first and only complete reference guide to welding, cutting, brazing, plus auxiliary equipment and supplies, has just been published. Compiled and edited by the editors of *Industry & Welding* and *Welding Illustrated* magazines, the 680-page directory lists more than 350 products, 1700 different trade names and more than 2000 welding distributors. It is conveniently divided into five sections. The first is a directory of welding, cutting, brazing and auxiliary products, all grouped alphabetically under major headings, sub-divided and cross-indexed for ease of reference. Section II — the Trade Names Index — presents a complete, up-to-date, alphabetical listing of all trade names, description of products, names and locations of manufacturers, and reference to page numbers of advertising and catalog pages. The Manufacturers' Catalog Section, Section III, consists of an alphabetical arrangement of catalogs, catalog sheets, specification data and special advertisements, describing all types of welding and allied equipment and supplies. It also includes a convenient index showing home office or main plant locations of manufacturers, plus local sales outlets and branch offices. The Fourth Section is a reference manual containing welding, cutting, brazing and application data. This easy-to-use reference section details a wide variety of practical, technical and engineering problems and their solutions. Comparative data on all types of welding electrodes, machines and accessories, plus "how-to-do-it" articles, charts, tables, etc., are also included. The last section, "Where To Buy It Locally", is carefully indexed and geographically and alphabetically arranged for ease of reference, and lists all lines carried and services offered by leading distributors, dealers and jobbers. Copies of The Welding Directory may be ordered at $6.50 each, from The Industrial Publishing Corporation, 812 Huron Road, Cleveland 15, Ohio.

FITTINGS FOR HYDRAULIC HOSE

Newly issued Catalog 4440 describes reusable Hoze-lok fittings for use with rubber covered wire braided hydraulic hose in sizes from 3/16 through 1-1/8 inches inside diameter. Fittings are no-skive type, therefore the cover of the hose need not be stripped off for assembly of fittings. Connecting ends offered include male pipe thread, straight thread with O-ring for SAE straight thread boss, Triple-lok 37° flare end, and swivel nut to mate with Triple-lok flare end. A catalog listing hose and hose assemblies, as well as giving instructions on how to make up assemblies is available from W. D. Wynant, Parker Fittings & Hose Division, Parker-Hannifin Corporation, 17325 Euclid Avenue, Cleveland 12, Ohio.

ANSUL BROCHURE AVAILABLE

A new brochure, the "Fire Protection Service Plan," published by Ansul Chemical Co., points out how a company can do a complete job of protecting itself against damaging fire loss. The "service plan" emphasizes the need for fire fighting training and fire prevention planning. It also explains other plus services available to users of Ansul equipment namely, in-plant fire protection survey, visual aids for training meetings, fire control training and demonstrations, fire school for supervisory personnel. For a copy of "Fire Protection Service Plan," write to J. R. West, Technical Services Director, Ansul Chemical Co., Marinette, Wis.

CATALOG PAGE DESCRIBES POLYETHYLENE TANKS

A new catalog page, illustrating and describing its enlarged line of standard polyethylene tanks has just been published by the American Agile Corporation. All tanks described are self-supporting, light in weight, chemically inert and non-contaminating. The free literature covers cylindrical, self-supporting tanks of 55-gallon capacity, square, self-supporting tanks of 25-gallon capacity, and 20 inches x 12 inches x 20 inches rectangular, self-supporting tanks. In addition, six examples of custom-engineered polyethylene tanks and liners are shown and described. Copies may be obtained from the American Agile Corp., P. O. Box 168, Bedford, Ohio.

PUMP BULLETIN AVAILABLE

A 12-page illustrated bulletin on Kobe triplex pumps has been issued by the manufacturer. These pumps are in use in many industrial plants where high pressure (up to 20,000 psi) and high temperatures (in excess of 500°F) are required. Applications include operation of hydraulic test equipment, molding presses, lubricating systems, oilwell pumping and others. Complete description of the pumps and their ratings are contained in the bulletin. Copies are available on request from Kobe, Inc., 3040 E. Slauson Avenue, Huntington Park, California.

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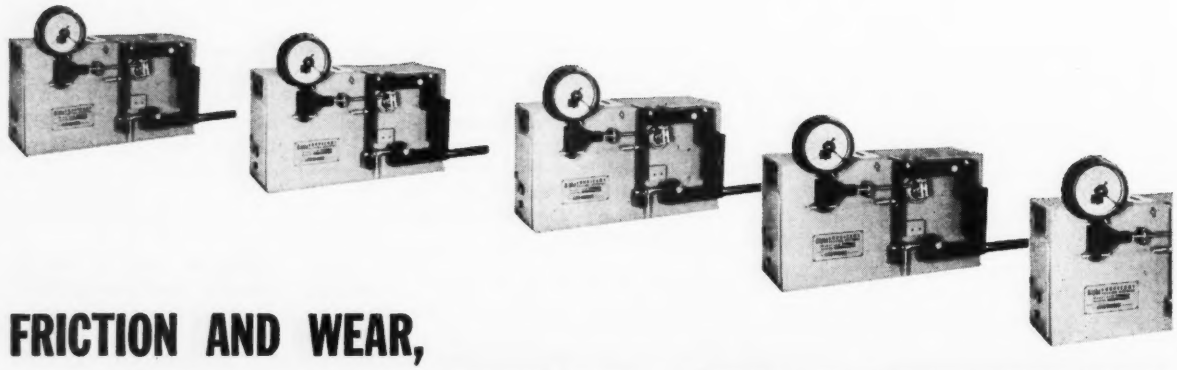


FRICTION AND WEAR, LIKE METAL FATIGUE PROBLEMS, DEMAND COMPREHENSIVE TESTING TO BREAK DOWN THE APPARENT COMPLEXITY

Complete isolation of individual effects is necessary to determine the influence of each condition on boundary lubrication

Although many complex phases of engineering have something in common, there is an uncanny parallel in the study of frictional effects and fatigue effects in metals.

The complexity of fatigue of metal problems involved such effects as metallurgical composition, geometrical shape, size, surface geometry, residual stresses, atmospheric environment, metal working and assembly-induced stresses. Since little was known about the full influence of any of these conditions on fatigue, full-scale simulated service testing of structures and assemblies allowed only composite analyses of these effects. In these composite analyses, however, large variations existed and researchers were unable to pinpoint the particular effect which accounted for the variations.

TESTING IN DETAIL PRODUCED RESULTS

With the advent of World War II, aircraft and military developments forced a more systematic approach to the problem of metal fatigue. A large number of small and relatively inexpensive testing machines were installed to investigate individual effects which were known or presumed to make up the complexity. This approach produced results.

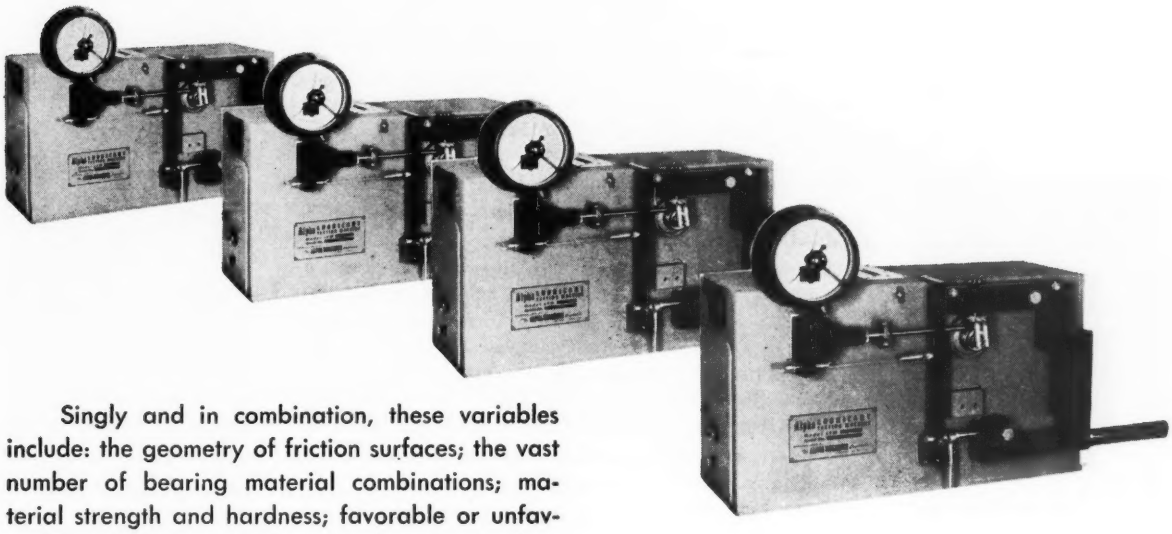
Concentrating on metallurgical composition brought about a knowledge of the decrementary effect of inclusions near the surface. Tests concentrating on geometrical shape disclosed reductions of fatigue strength due to abrupt changes of specimen contour. Surface geometry tests showed the strength-reducing effects of sharp notches. Tests for residual stresses revealed the beneficial effects of surface compression stresses and the detrimental effects of surface tension stresses. Atmospheric environment tests showed the strength-reducing effects of even minor surface corrosion.

Full-scale testing could never have isolated these effects. It wasn't until millions of hours of testing were conducted on small machines that many of the complex phases of fatigue life were cleared up. This made full-scale testing productive and economical.

SAME APPROACH NEEDED FOR FRICTION AND WEAR EFFECTS

The complexity of boundary lubrication rivals the complexity of metal fatigue. It needs, and will receive, increasing attention! Millions of hours of testing must go into the effort to isolate and determine the significance of a multitude of damaging or beneficial effects.

THE BETTER THE TESTING EQUIPMENT . . .
THE LOWER THE COST OF PRODUCTIVE RESEARCH



Singly and in combination, these variables include: the geometry of friction surfaces; the vast number of bearing material combinations; material strength and hardness; favorable or unfavorable formation of surface deposits; surface oxidation; the influence of frictional heat on the bearing metals and the lubricant; bearing pressures; sliding velocity; and so on.

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1958 Annual Meeting Abstracts

Editor's Note: The following abstracts and photographs include only those available as of the closing deadline for the April issue. For instruction on ordering preprints see page 179.

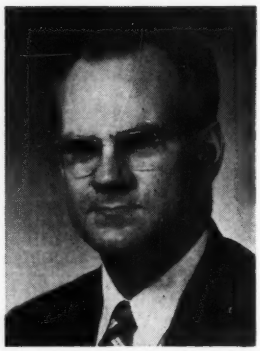
C. E. Schmitz

EFFECT OF NEW E-P LUBES ON ELASTOMERS FOR OIL SEALS. J. Murray, Chicago Rawhide Mfg. Co., Chicago, Ill.

A review of test experience with new extreme-pressure lubricants: their effects on synthetic rubbers of all types. *Preprint No. 58AM 1A-1.*

ANALYSIS OF MAJOR CAUSES OF MECHANICAL SEAL FAILURES. C. E. Schmitz, Crane Packing Co., Morton Grove, Ill.

The paper will discuss the major causes for mechanical seal failures. By slides we will illustrate the failures and propose ways and means for prevention of such failures. *Preprint No. 58AM 1A-2.*



R. F. McKibben

F. P. Downing

MAINTENANCE OF LUBRICATING OIL QUALITY WITH CENTRIFUGAL PURIFICATION. F. P. Downing, The Sharpless Corp., Philadelphia, Pa.

The design and operation of the centrifugal oil purifier is governed by the variables set forth in Stokes Law. Centrifugal force, density difference, fluid viscosity, and particle diameter are factors affecting the operation of the tubular and disc type centrifuge. Proper adjustment of the centrifuge and maintenance of proper operating conditions are required for satisfactory purification, particularly with the handling of highly emulsified feeds. Low moisture content in the clarified oil, as well as the removal of micron size particles, can be achieved with proper centrifugal operation. *Preprint No. 58AM 1B-1.*

A. H. Lipton

T. W. Potter

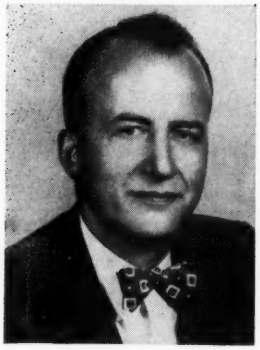
ECONOMICS OF OIL RECLAMATION FOR RAILROAD EQUIPMENT. T. W. Potter, Journal Box Servicing Corp., Chicago, Ill.

The article covers, as part of the introduction, a brief development of the reclamation of oil for railroad equipment with statistics and detail almost confined to lubrication of railroad cars. There will be comparative analysis of the oils before and after reclamation and the statistics will be extended to cover the American Railroads. *Preprint No. 58AM 1B-2.*

RECOVERY OF USED CUTTING OILS. A. H. Lipton and R. F. McKibben, National Cash Register Co., Dayton, Ohio.

Material removed by centrifugal recovery equipment has been related to operating characteristics of screw machines. Resinous products, formed as the result of normal use of cutting oils, can seriously detract from satisfactory machine operation. Effective removal of resinous

W. M. Kauffmann



W. C. Conover

contaminants may be the most important factor to consider in large scale re-use of cutting oils. *Preprint No. 58AM 1B-3.*

HEAVY DUTY HIGH OUTPUT INTERNAL COMBUSTION ENGINE LUBRICATION. W. M. Kauffmann, Worthington Corp., Buffalo, N. Y.

Reliable performance of heavy duty high output diesel and gas engines depends upon design of components to reduce thermal gradient of critical parts. Lubrication problems are reduced by correct bearing load, improved engine design, and heat transfer. Turbocharging is firmly established as a means of increasing output. Lubrication of turbocharger becomes an important factor in trouble-free operation. *Preprint No. 58AM 1C-1.*

M. Petronio

W. L. Stewart

LUBRICATION REQUIREMENTS OF TWO-CYCLE OUTBOARD MOTORS. W. C. Conover, Outboard Marine & Mfg. Co., Waukegan, Ill.

This paper will present the overall scope of the outboard industry and its uses of fuel and lubrication oil. Particular emphasis will be placed upon the problems of lubricating the two-cycle outboard motor.

The paper is presented in the hope that it will stimulate industry cooperation on lubricating problems in this rapidly increasing market. *Preprint No. 58AM 1C-2.*

W. M. Pelino

P. C. Paterson

APPLICATIONS FOR SOLID LUBRICANTS ON TURRET LATHES. K. L. Davis, Jr., Warner & Swasey Co., Cleveland, Ohio.

A discussion of the use of solid lubricants and their application to collect mechanisms on turret lathes. Application of solid lubricants to lockbolt bushings will be discussed. *Preprint No. 58AM 2A-2.*

J. B. Accinelli

LUBRICANTS FOR FORMING OF ALUMINUM. M. Petronio, Frankfort Arsenal, Philadelphia, Pa.

A number of lubricants of known composition were evaluated in a laboratory slow-speed draw test by determining the forces obtained during the drawing of a caliber .30 aluminum cartridge case. It was learned that conditioning of the aluminum surface prior to drawing is very important and should be considered equally as important as the liquid drawing lubricant. This study includes therefore an investigation of several surface pretreatments such as various pickling and alkali treatments, phosphating, and oxidation by both electro chemical and chemical immersion methods.

Shop test results are reported corroborating laboratory findings in the drawing of 75S, 24S and 52S aluminum alloys. There is reported also limited shop test data showing that hot forging and cold extrusion of aluminum are facilitated by the use of an oxide pretreatment. *Preprint No. 58AM 2A-3.*

G. S. Reichenbach

DESIGNING AND TESTING JOURNAL BOX SEALS. W. L. Stewart, American Brake Shoe Co., Mahwah, N. J.

The paper discusses the design problems encountered in developing a journal box seal for railway equipment. Included is a discussion of the test program established to determine the merits of journal box sealing devices with descriptions of the test equipment used. *Preprint No. 58AM 2B-1.*

S. J. Beaubien

F. W. Jones

Application of Infrared Pyrometry Techniques to Hot Box Detection. W. M. Pelino, Servo Corporation of America. New Hyde Park, N. Y.

Historical comments are made by way of review concerning causes of hot boxes. Present methods of hot box detection are discussed as to their inadequacies. Introduction of the Servosafe® Hot Box Detective system is made as an answer to reliable detection of hot boxes while trains are in transit. Statistics are presented to indicate the expected reliability of the system in the present state of the art. Slide illustrations of performance characteristics are given. The Servosafe® system is described.

Present and future benefits derived in operating costs are discussed briefly in the light of new A.A.R. proposals for handling damaged journals. *Preprint No. 58AM 2B-2.*

J. W. Gaynor

E. A. Dieman

Lubrication of High-Speed, High Temperature, Thrust Ball Bearings. J. B. Accinelli and S. J. Beaubien, Shell Development Co., Emeryville, Calif., and G. S. Reichenbach, Massachusetts Institute of Technology, Cambridge, Mass.

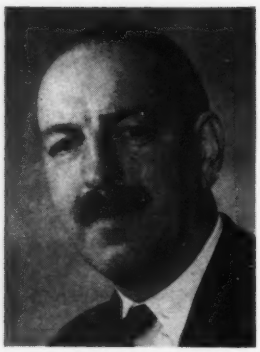
High temperatures impose special problems on the operation of high speed axially loaded ball bearings. Among these are fatigue, lubricant deposits, and aggravated friction and surface damage at areas of metal contact. This paper is concerned only with the friction and surface damage aspects of the problem. Since a small scale bearing was to be used in the experimental work, an analysis was made of spinning, one of the major friction sources, and the small-scale operating conditions were chosen to give ball-to-race surface temperatures approaching, as near as practical, the corresponding temperatures for full-scale bearings.

Bearing rig tests in a once-through jet lubrication system with silicone fluid, mineral oil, and a synthetic ester lubricant resulted in friction failures at approximately 350°F, 650°F, and 800°F, respectively. This is in agreement with full-scale experience and lends support to the validity of the rig tests. With oil-air mist lubrication failure occurred at a much lower temperature. This was probably due to insufficient lubricant to provide for a hydrodynamic component of mixed friction at the contact zone or to a failure to provide any lubricant at all due to volatilization of the oil. Two E.P. additives used in mist lubricated systems did not give appreciable improvement probably because of the stainless steel test bearings. It was demonstrated that deposits from lubricant decomposition did not play a significant role in the above results and thus it could be concluded that the small scale rig emphasized the deposit-free high temperature friction properties of lubricants. *Preprint No. 58AM 2C-1.*

L. O. Brockway

M. Antler

L. M. Niebylski



F. T. Barwell

Test Procedures for the Sikorsky Aircraft Friction Oxidation Tester. F. W. Jones, Sikorsky Aircraft Co., Bridgeport, Conn.

A short description of friction oxidation, its importance to helicopters and the need for a device to select greases in accordance with friction prevention. The friction oxidation tester is described briefly, and its use for grease selection. *Preprint No. 58AM 2C-2.*

E. H. Loeser

S. B. Twiss

THE WADC DEPOSITION TEST. H. R. Smith, Wright Air Development Center, Wright-Patterson AFB, Ohio.

The need for a satisfactory screening test for engine deposit rating is outlined. A brief history of the development of apparatus and procedures to this end are given. A description of the WADC Deposition Rig and test procedure is given. Correlation data between engine deposits and rig results are presented. The effects of various operating variables are illustrated. Future research and development work with the apparatus and test procedure are outlined. *Preprint No. 58AM 2C-3.*

R. C. Wiquist

H. Sellei

THE ACCELERATED CONDENSATION CORROSION TEST FOR EVALUATING RUST PREVENTIVES. E. A. Dieman and J. W. Gaynor, Standard Oil Company (Indiana), Whiting, Indiana.

A new test — the Accelerated Condensation Corrosion Test — has been developed for quality control of rust preventives. The test features short testing time and good precision. Short testing time is obtained by accelerated condensation on the test panels. Good precision is obtained by close control of condensation and by use of a new panel-preparation procedure in which the panels are water-treated. Testing times are 1/20 to 1/50 of those obtained in JAN-H-792 humidity-cabinet tests. Repeatability is about three times as good. *Preprint No. 58AM 2C-4.*

P. A. Smith

M. C. Shaw

INVESTIGATIONS OF WEAR BY ELECTRON DIFFRACTION. L. M. Niebylski and M. Antler, Ethyl Corp., Detroit, Mich., and L. Brockway, Univ. Mich., Ann Arbor, Mich.

A brief review of the principles of electron diffraction, the advantages of the electron diffraction technique to wear studies, and the experimental results obtained by electron diffraction in specific applications which will include: (A) Monolayer film studies, (B) Polished layers, (C) Lattice orientation at metal surfaces after abrasion, (D) Piston ring wear, (E) Solid lubricants, and (F) Surface imperfections and catalysis. *Preprint No. 58AM 3A-1.*

P. Loewenstein

R. H. Cottrell

TECHNIQUES FOR SURFACE EXAMINATION AND THEIR CONTRIBUTION TO OUR KNOWLEDGE OF FRICTION AND WEAR. F. T. Barwell, Mechanical Engineering Research Laboratory, Thorntonhall, Glasgow, Scotland.

This paper presents a critical examination of advances and limitations of modern methods of studying surfaces including electron and optical microscopy, radioactive techniques and the newly developed electron emission methods. *Preprint No. 58AM 3A-2.*

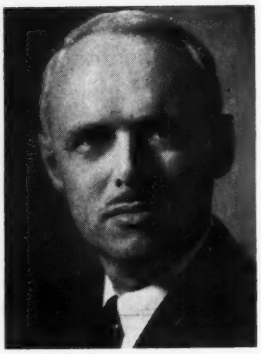
ANALYSIS OF FILMS FORMED BY RADIOACTIVE E-P ADDITIVES. E. H. Loeser and S. B. Twiss, Chrysler Corporation, Detroit, Michigan.

Relatively little use has been made of radioactive tracers in oil additives for the study of extreme pressure lubrication. This review of the literature is concerned with the analysis of films containing radioactive carbon^{14} (in carboxyl group), radioactive phosphorus^{32} and radioactive sulfur^{35}, which are formed from reactive oil additives on metal surfaces. The purpose of this review

J. J. Slomer

C. E. Moss

was to establish general principles of the mode of action of chemically reactive additives. The majority of the work reported dealt with static immersion of metal specimens in the radioactive oil; a few reports were concerned with film formation under dynamic test conditions. Activity of the additive appeared to be a function of concentration, temperature, pressure, nature of the wear surface and presence of other reactive oil additives. Determinations of radioactivity on the metal surface were generally made by means of Geiger-Muller counters and autoradiographs. The latter technique was particularly useful in dynamic tests to show the effect of pressure distribution on the wear surfaces. *Preprint No. 58AM 3A-3.*



A. H. Burr

CAM AND TAPPET LUBRICATION. III — RADIOACTIVE STUDY OF PHOSPHORUS IN THE E-P FILM. E. H. Loeser, R. C. Wiquist and S. B. Twiss, Chrysler Corporation, Detroit, Michigan.

R. C. Elwell

A radioactive tracer, phosphorus^{32} synthesized into zinc dialkyl dithiophosphate molecules, was used to study the E-P films formed by this motor oil additive on cast iron cams and tappets. The tightly bound films, which contain phosphorus and zinc, formed rapidly and then leveled off to steady-state values in static and dynamic tests. The amount of film increased with oil temperature (200 to 300°F) and with roughness of the metal surface. Dynamic test conditions greatly increased the amount of film formed, indicating the marked effect of surface temperature, pressure or wear. A steady-state film is maintained on parts run in additive oil; moreover, the film was not easily worn off in non-additive oil. The chemical and physical properties of the films appeared to vary with the conditions of film formation. Radioactive counting was used to determine the film on tappets and the thermal stability of the oil; autoradiographs showed the concentration and distribution of the film on cams and tappets. *Preprint No. 58AM 3A-4.*

G. R. Fox

R. D. Clouse

MEASURING OF SULFUR ACTIVITY AT HIGH TEMPERATURES. Helen Sellei, Research Department, Standard Oil Company (Indiana), Whiting, Indiana.

A method has been developed for quantitatively measuring the corrosiveness towards copper of active petroleum additives containing sulfur. A dilute solution of the sulfur additive is simply heated in a test tube with a copper strip at 200 to 400°F. Such reaction products as do not flake off are removed from the strip by washing with dilute potassium cyanide. The weight loss of the strip is the measure of corrosiveness. The change in weight loss with time and temperature, can be used to characterize the activity of sulfur additives. *Preprint No. 58AM 3A-5.*

A. Shapiro

H. Gisser

WORKPIECE COMPATIBILITY OF CERAMIC CUTTING TOOLS. M. C. Shaw and P. A. Smith, MIT, Cambridge, Mass.

It is now well known that certain types of cemented carbides give excellent results when used to cut cast irons but poor results when used to cut steels and vice versa. This relative ability of a given tool material to perform well when cutting a given workpiece material is referred to here as *compatibility*.

L. Teitell

S. Berk

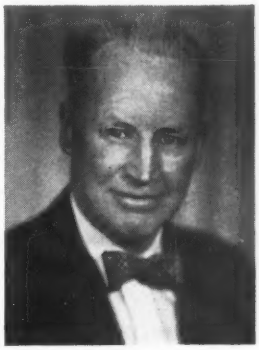
Ceramic metal cutting tools have been in use in machining metals such a short time that it is not yet generally known on which materials these tools can be used to best advantage. In this report the performance of ceramic and cemented carbide tools is compared when machining a wide variety of metals. It is found that there are certain metals for which either the surface chemical or thermal characteristics of ceramic tools are particularly advantageous.
The report is concluded by a table which lists a large number of ferrous and nonferrous metals in order of decreasing compatibility with aluminum oxide tools. *Preprint No. 58AM 3B-1.*

C. D. Fisher

H. Muller

LUBRICATION PROBLEMS IN THE FABRICATION OF NUCLEAR REACTOR METALS. P. Lowenstein, Nuclear Metals, Inc., Cambridge, Mass.

Metals used in the construction of nuclear reactors are "reactive." They present a severe problem in galling, or "pick-up" on tools in fabrication processes involving friction. The problems and several solutions are presented for cold working operations, illustrated by wire and tube drawing, hot-working operations illustrated by extrusion. One of these "lubrication" techniques led to the development of "canning," which today is one of the most important methods for the production of clad fuel elements. *Preprint No. 58AM 3B-2.*



F. Hardy

INDUSTRY LOOKS AT AUTOMATION IN LUBRICATION. R. H. Cottrell, Sheffield Div. Armco Steel Co., Kansas City, Mo.

The rapid spread of modern lubrication practices has very definitely played an important role in the reduction of machine down time normally required for lubrication purposes. The extended machine life can be directly related to improved modern lubrication techniques and preventive maintenance programs.
The actual cost of equipment and installation can be payed for by the reduction of time normally required to lubricate the machine. The time required for installation and cost of the automatic equipment depends on the complexity of the machine, therefore, the more complex the operation the greater the labor saving and the shorter the time required to retire the cost of auxiliary equipment. *Preprint No. 58AM 3C-1.*

G. L. Duke

R. G. Grothus

CENTRALIZED LUBRICATION IN THE TEXTILE INDUSTRY. C. E. Moss, Firestone Textile Div., Firestone Tire and Rubber Co., Gastonia, N. C.

U. S. consumption of textiles will reach the rate of 9 billion pounds per year for 1975. At the rate of mill modernization present spindles will not anywhere near take care of the need for it in one decade. The key to this problem is mill modernization on an accelerated rate and for a productive maintenance program. *Preprint No. 58AM 3C-3.*

C. R. Galbreath

P. J. Galbreath

THERMAL EFFECTS IN THE FLOW OF FLUIDS BETWEEN TWO PARALLEL FLAT PLATES IN RELATIVE MOTION. G. Reethof, C. Goth, and H. Kord, Vicker's Inc., Detroit, Mich.

The behaviour of oil hydraulic positive displacement machines is primarily determined by the viscous flow of

fluid through closely spaced parallel surfaces. In this study the shear work induced temperature rise in a parallel plate bearing of infinite width is studied. The effect of this temperature rise on the viscosity and density of the fluid is determined. Nondimensional curves of load carrying capacity, clearance and temperature rise for several typical hydraulic fluids are given. An experimental verification of the parallel plate bearing theory shows good agreement with theory within the assumptions of no end leakage. *Preprint No. 58AM 4A-1.*

THE EFFECT OF SHAFT ROTATION ON BEARING TEMPERATURE. A. H. Burr, Cornell University, Ithaca, N. Y.

Heat transfer data from recent studies of rotating cylinders are utilized in the heat balance method of predicting oil film temperatures for shaft and plain bearing combinations. Good agreement is obtained between calculated temperatures and experimental values. It is shown that heat dissipated from a rotating shaft may be much greater than that from a stationary shaft and from the bearing housings, and it may be the major path for heat dissipation in certain cases. *Preprint No. 58AM 4A-2.*

RADIOACTIVE DETERMINATION OF BEARING WEAR IN A REFRIGERATION COMPRESSOR. G. R. Fox and R. C. Elwell, General Electric Co., Schenectady, N. Y.

The lubricant and Freon-22 mixture viscosity in a hermetically sealed refrigeration compressor varies widely with changes in system pressure and temperature. In this paper theoretical load carrying capacity at different operating conditions is compared to actual bearing wear determined by radioactive methods. This technique allows a continuous and rapid evaluation of a complete fluid film bearing system. *Preprint No. 58AM 4A-3.*

MACHINABILITY OR CUTTING FLUID EVALUATION BY DRILLING TORQUE TEST. R. D. Clouse, California Research Corporation, Richmond, California, and E. R. Hall, Aerojet-General Corporation, Sacramento, California.

A laboratory power feed drill press has been used to determine the machinability of two new, high-strength stainless steels. As a result of these studies, a technique for evaluating cutting fluids has been developed which yields an optimum tool life rating as well as relative cutting efficiency. Drill press tool life data produced curves that are very similar to those determined from lathe tool life data as expressed by the Taylor equation ($Vt^n = C$). A simplified test method for shop use is provided. *Preprint No. 58AM 4B-1.*

RADIOACTIVE STUDY OF THE EFFECT OF LUBRICANTS ON METAL TRANSFER IN DRAWING BRASS. C. D. Fisher, A. Shapiro, S. Berk, M. Petronio, L. Teitell, and H. Gisser, Frankford Arsenal, Philadelphia, Pa.

A study of the effect of lubricants on metal transfer in a drawing operation using radioactive tracer techniques. The experimental system consisted of drawing a caliber .30 brass draw piece plated with brass containing zinc^{65} and measuring the radioactivity transferred to the die. Results showed that there is a continual interchange of brass between the die and the work and that the amount of brass transferred is related to the draw forces. Sulfurized lard oil and sulfurized mineral oil resulted in the largest amount of metal transfer. The radioactive tracer technique may be used to study metal transfer and to evaluate lubricants in the drawing operation. *Preprint No. 58AM 4B-3.*

THE DEVELOPMENT OF A TEST FOR EVALUATING GRINDING FLUIDS. R. D. Halverstadt, AGT Div., General Electric Co., Cincinnati, Ohio.

Opinion rather than fact, is usually the basis of grinding and cutting fluid selection. There has been sufficient data for a long time to show that the selection of grinding fluids has deserved more emphasis. During the past several years, a series of actual grinding tests have been conducted to evaluate the various types of grinding fluids. Each different test attempted to take into consideration some new facet of the various important factors. Thus, a test was evolved which measured the effect of the fluid grinding forces, grinding ratio, surface finish, and surface damage. The surface damage can be considered in terms of residual surface stress, microgeometry, or microstructural changes at or near the surface. It is shown that a measure of each one of these important criteria can point with factual data to the grinding fluid which best suits a particular job. Selection can then be made on the basis of fact and need with relatively little opportunity of "chance" affecting the decision. *Preprint No. 58AM 4B-4.*

C. L. Miller

W. J. Anderson

T. L. Carter

J. R. Coombe

MARKETING AND TECHNICAL SERVICE: THE RIGHT LUBRICANT. H. Muller, Shell Oil Co., New York, N. Y.

The right lubricant supplied by a major oil company is a composite of basic formulation, application research and technical service. Technical service rendered to the plant lubrication engineer comprises analysis of application, recommendation of proper lubricant and sound lubrication maintenance methods, and trouble shooting. Aids in accomplishing this service are plant lubrication surveys, manufacturers' recommendation charts, and assistance in training plant lubrication personnel. *Preprint No. 58AM 4C-1.*

RESEARCH AND APPLICATION: DEVELOPMENT OF SPECIAL LUBRICANTS AND LUBRICATION PRACTICES FOR SMALL APPARATUS. F. Hardy, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

Only by becoming thoroughly familiar with the functioning of any small piece of apparatus is it possible to intelligently determine the kind of lubrication the apparatus requires. With such a background, the lubrication engineer is able to determine the type of lubricant required and how it shall be applied. The development of specialized lubricants and lubrication practices often extends life many fold, obviates relubrication in service, or if relubrication is necessary, the periods between relubrications may be greatly extended. Two typical pieces of telephone equipment are used for demonstration purposes, and the methods of approach explained. Comments are added on the significance of the four R's of lubrication; the right lubricant, the right quantity, in the right place at the right time. The right lubricant is only one of the R's, sometimes the right quantity of lubricant, or determining means of getting the right quantity in the right place is even more important. *Preprint No. 58AM 4C-2.*

PURCHASING: THE RIGHT LUBRICANT AT THE RIGHT PRICE. G. L. Duke, Westinghouse Electric Co., Pittsburgh, Pa.

The paper will deal with the problems faced by the lubricant buyer in assuring himself that he is obtaining maximum value of the dollars spent.

We will endeavor to outline some of the methods which can be used, and will recommend, for consideration, proven methods to accomplish the desired goals.

The particular method to buy lubricants must be correlated from many factors, such as size of plant, type of product being manufactured, volume and other considerations. The main theme, however, will be the necessity of a planned program. *Preprint No. 58AM 4C-3.*

PLANT PRACTICES IN LUBRICATION AND PREVENTIVE MAINTENANCE. R. G. Grothus, Bell and Howell Co., Chicago, Ill.

Through the concept of this presentation you will see how a man in a manufacturing industry has set up a preventive maintenance program from the first step to the final operation over a five-year period. His talk will cover inventory of machinery, record systems, fundamentals of selection of lubricants, automatic lubrication, handling, storage and a detailed description of how a predetermined automatic lubrication route system works. *Preprint No. 58AM 4C-4.*

MECHANIZED SCHEDULING OF LUBRICATION. C. R. Galbreath, Caterpillar Tractor Co., Decatur, Ill.

Details of the methods and procedures used in the machine scheduling of lubrication at the Decatur Plant of Caterpillar Tractor Co. *Preprint No. 58AM 4C-5.*

THE RIGHT QUANTITY. P. J. Galbreath, Tennessee Eastman Co., Kingsport, Tenn.

The right quantity is generally defined as using the proper lubricant in amounts as required. This nebulous statement leads to many practices, and plenty of latitude to do as you see fit. Our discussion will be confined to some of the effects of the right quantity. *Preprint No. 58AM 4C-6.*

ECONOMICS OF ANTI-FRICTION BEARING INSPECTION IN INDUSTRIAL PLANTS. C. L. Miller, Eastman Kodak Co., Rochester, N. Y.

This paper will present the economics of an anti-friction bearing inspection and cleaning program from experience at Kodak Park. Four years of operating a bearing test center has revealed many interesting facts about both new and used bearings. For example: From the 100 percent inspection of new bearing shipments, it has been found that over 10 percent contain defects such as brinell marks, nicked balls, etc. These defective bearings can be sorted out prior to installation with appropriate test equipment. This paper will describe the construction of a bearing center and the necessary cleaning and testing equipment. Cleaning procedures will be discussed with the emphasis on experience with ultrasonic cleaning. The

A. I. Sippola

J. W. Armstrong

B. E. Gordon

J. R. A. Handschy

discussion of inspection or testing procedures will be concentrated on noise testing methods to determine defects rather than physical dimensional tests. The noise test is currently performed by a skilled operator judging bearing quality by ear. This paper will present a method for manufacturers and users to test bearings by vibration equipment. Thus, a numerical value could be placed on bearing quality. *Preprint No. 58AM 5A-1.*

EFFECT OF LUBRICANT VISCOSITY AND TYPE ON BALL FATIGUE LIFE. W. J. Anderson and T. L. Carter, NACA, Cleveland, Ohio.

Two separate investigations were conducted to determine the effect of lubricants on the fatigue life of M-1 tool steel balls in the rolling contact fatigue spin rig. In the first investigation four paraffinic mineral oils with viscosities of 5 to 113 centistokes at the 100°F test temperature were used. Life varied approximately as the 0.2 power of lubricant viscosity. In the second investigation a methyl silicone, a paraffinic mineral oil, a sebacate, a water base glycol and an adipate, each of which had a viscosity of about 10 centistokes at the 100°F test temperature, were used. The 10 percent life was about 40 times as great with the silicone (best) as with the adipate (poorest). The life results correlated fairly well with the pressure viscosity characteristics of lubricants of the same base stocks. *Preprint No. 58AM 5A-2.*

RADIOACTIVE MEASUREMENT OF BALL BEARING WEAR. J. R. Combe, General Electric Co., Lynn, Mass.

A series of ball bearing wear tests was made using radioactive balls in an SKF7215 ball bearing. A range of applied loads and speeds were used and the wear at these parameters determined. The test equipment and methods of testing are described. *Preprint No. 58AM 5A-3.*

A RECENT ADVANCEMENT IN THE DEVELOPMENT OF EXTREME-PRESSURE GREASES. A. I. Sippola, Soconoy-Mobil Oil Co., New York, N. Y.

Multi-purpose grease development trends have been extended to E-P greases to permit their use at increasingly higher temperatures as well as higher loads. To attain this objective, key characteristics, such as pumpability in central systems, have been retained. This has necessitated re-evaluation of conventional E-P formulations. Development work has relied on field evaluations to demonstrate whether the new formulations were truly multi-purpose products. *Preprint No. 58AM 5A-4.*

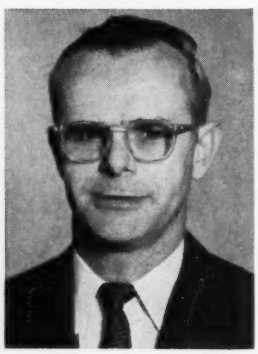
GREASES STABLE TO RADIATION UNDER DYNAMIC CONDITIONS. J. R. A. Handschy, J. W. Armstrong, and B. F. Gordon, Shell Oil Co., Martinez, Calif.

Conventional greases exhibit marked changes in physical properties upon exposure to large doses of high-energy radiation. Heretofore, these changes have been evaluated in the usual bench-scale tests after irradiating the greases in vials under static conditions. While this method is quite effective in identifying and eliminating those products most susceptible to radiation damage, it yields little information on the progressive degradation of greases under the combined effects of simultaneous irradiation, oxidation, and mechanical working typical of actual service. To overcome this limitation, a modification of the Shell Roll Tester suitable for underwater operation has been developed and installed in the Gamma Facility pool at the Materials Testing Reactor, Idaho Falls, Idaho. Details of this test rig are presented in the text. The equipment permits periodic examination of the degradation in mechanical stability of grease under dynamic irradiation conditions. Mechanical stability has been found to be the parameter most sensitive to radiation.
The screening of many greases and grease components under both static and dynamic conditions has indicated the thickeners and oils which show the greatest resistance to radiation degradation. Greases prepared with these components retain a good measure of their initial serviceability even after absorbing more than 5×10^8 roentgens. *Preprint No. 58AM 5B-1.*

INVESTIGATION OF FACTORS AFFECTING HIGH-TEMPERATURE GEAR OPERATION. E. E. Shipley, General Electric Co., Lynn, Mass.

The aircraft industry as a whole was one of the first groups to become deeply involved in high temperature gear operation. On the surface, it seemed that new and improved lubricants might be the answer, but if temperatures increased much beyond 350°F, a new look at the gear material situation would be in order.
From an engineering point of view, it was agreed that the only sure way to find the correct solution to the high temperature problem would be to build a full-sized full-load gear-test facility and duplicate expected field conditions on a test stand. In order to carry out a gear test

E. E. Shipley



J. E. Parkin

W. Kloc

H. L. Worthington

program, a considerable amount of laboratory material and lubrication evaluation was undertaken. The lubricant phase consisted of running tests on oxidation stability, thermal stability, and wear tests.

The material phase (test made at 500°F) tests were made on: pneumatic fatigue tester, hot hardness tester, charpy impact tester, and pinion fatigue tester.

Running tests have been made on: lubricated roll test machine and high temperature gear test machines. *Preprint No. 58AM 5B-2.*

LUBRICATION OF MISSILES AND MILITARY AIRCRAFT. J. E. Parkin, Chance-Vought Aircraft Co., Dallas, Texas.

Each new aircraft developed today is designed to fly faster and higher than its predecessors, but before the design leaves the drawing boards new lubricants must be made available for it. Each new barrier, whether it is one of location, of speed, or of altitude, presents new challenges to aircraft lubrication engineers.

To be applicable in modern fighter aircraft, lubricants must perform adequately within a temperature range of —65°F to 300°F and, in special cases, to 500°F. The excessive temperature from friction as the aircraft flies through the atmosphere is a major problem to aircraft lubrication engineers.

By seeing military aircraft perform, we can more fully appreciate the rigid demands imposed upon their lubricants, lubricants that are satisfactory today, but that might have to be replaced tomorrow with compounds as yet unknown — compounds that might have to lubricate at speeds of Mach 10 to 20. *Preprint No. 58AM 5B-3.*

CENTRALIZED LUBRICATION IN PRODUCTION FOUNDRIES. W. Kloc, Chevrolet Division, General Motors Corp., Tonawanda, N. Y.

The paper will cover various types and sizes of centralized system installations on foundry equipment, the advantages and savings by centralized equipment, the problems encountered with lubricants in centralized systems and how these problems were resolved. *Preprint No. 58AM 5C-1.*

CENTRALIZED LUBRICATION FOR PRODUCTION MACHINERY. H. L. Worthington, Remington Arms Co., Inc., Bridgeport, Conn.

The advantages and benefits derived from centralized lubrication systems include: improved safety, good housekeeping, continuous production, preventive maintenance, and cost reduction.

Problems and difficulties that arise with centralized lubrication systems include: poor layout or installation, lack of knowledge of the operating principles and maintenance of the system, lubricant contamination (foreign materials), and periodic inspection. *Preprint No. 58AM 5C-2.*

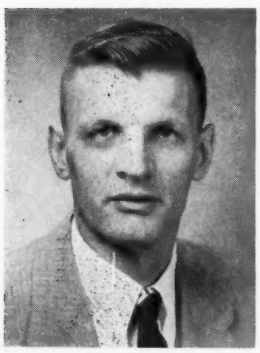
AUTOMATIC CENTRALIZED LUBRICATING SYSTEMS FOR CONCRETE BLOCK MACHINERY. D. Knechtel, Besser Co., Alpena, Mich.

A brief history of the development of concrete block machinery from the year 1904 to the present.

Automatic centralized lubrication has proven very successful with two systems having been used, namely, the centralized air-borne and the centralized grease system. Advantages and disadvantages as applied to our field regarding two systems will be discussed as to use under adverse conditions prevalent to the concrete block making industry. It will also be brought out as to how the automatic centralized lubrication system has justified itself from a safety, practical and economical viewpoint. *Preprint No. 58AM 5C-3.*

DETERMINATION OF OPTIMUM PROPORTIONS FOR HYDROSTATIC BEARINGS THROUGH THE USE OF THE ELECTRIC ANALOG FIELD PLOTTER. A. M. Loeb and H. C. Rippel, Franklin Institute, Philadelphia, Pa.

The effect of recess size on the pressure, flow and power requirements of several hydrostatic bearing configurations is described in terms of dimensionless coefficients called performance factors. Performance factors are determined analytically for a simple hydrostatic step bearing, compared graphically with the electric analog solutions for this bearing and found to be in excellent agreement. The electric analog approach is also used to determine the performance factors for several other bearing configurations for which there is no known analytic solution. These data are presented in the form of dimensionless curves. It was found that for a given bearing configuration, there is a particular recess size which will give minimum power. Where limiting factors such as pump output pressure and/or flow do not dominate, it is suggested that bearings be designed to operate at the minimum power point. *Preprint No. 58AM 6A-1.*



D. Knechtel

A. M. Loeb

H. C. Rippel

D. F. Hays

PLANE SLIDERS OF FINITE WIDTH. D. F. Hays, General Motors Research Laboratories. Detroit, Mich.

An analytical solution to the problem of the lubrication of slider blocks of fixed wedge angle and finite width is presented. The method of solution is by the separation of variables which yields results conveniently shown in curve form illustrating the various slider properties. The analysis is not encumbered by the requirement of numerical or graphical methods of evaluation as in the case of Michell, and is similar in nature to the solutions of Muskat, Morgan, and Meres wherein explicit analytical expressions are derived for the slider characteristics. The solutions appear in the form of convergent series.
The present analysis illustrates the manner by which the separation of variables in Reynold's Equation may be effected, completes the solution of the resulting eigenvalue problem, and shows the formulation of the expressions for load capacity, frictional resistance, center of pressure, coefficient of friction, and rates of flow. Typical pressure hills are shown as well as approximate flow patterns throughout the slider area. *Preprint No. 58AM 6A-2.*

WADC GEAR LUBRICATION RESEARCH AND DEVELOPMENT PROGRAM. H. R. Smith, WADC, Wright-Patterson AFB. Ohio.

This paper will discuss the program carried out by WADC on gear lubrication in regard to scuffing and fatigue studies, using the Erdee Universal Ryder Gear Rig. Performance data of various types of lubricants will be presented and the effect of variables will be discussed. *Preprint No. 58AM 6B-1.*

SOME LUBRICATION PROBLEMS IN HIGH SPEED GEARS. J. Derm, Steel Products Engineering Co., Springfield, Ohio.

This paper will discuss the lubrication problems involved in high speed gearboxes, based on experience in the development of one gearbox and application of the experience in the design of a second gearbox.
A discussion of the test results of the gearboxes, including the effect of short-time lubrication failure will be included. *Preprint No. 58AM 6B-2.*

SHOT PEENING IN RELATION TO GEAR-TOOTH SCORING. J. Straub, Wheelabrator Corp., Mishawaka, Ind.

Shot Peening is a process which is recognized as a means of increasing fatigue strength of machine parts. It has long been accepted as a means of correcting fatigue failures in existing designs, but the possibilities of the use of the process in the actual design of machine parts appear in general to be underestimated. Although the process is primarily a means of increasing fatigue strength, it may provide flexibility in the design of gears in areas other than fatigue strength. For example shot peening appears to have little or no direct influence on the scoring resistance of an existing pair of gears. However, in some cases scoring resistance can be increased by the use of a finer pitch. This may be a limited choice because of the loss of bending fatigue strength of the teeth. In such a case, shot peening can provide the necessary fatigue strength to permit greater freedom in this respect.

The increase in allowable bending stress due to shot peening is not the same for all conditions. A greater increase is obtained in applications requiring a long service life. Test results have indicated an increase of as much as 50% or more in allowable stress. *Preprint No. 58AM 6B-3.*

EMULSION-TYPE FIRE-RESISTANT HYDRAULIC FLUIDS — NEW DEVELOPMENTS REFLECT IMPROVED PERFORMANCE. C. E. Francis, Shell Oil Co., Martinez, Calif., and R. T. Holmes, Shell Oil Co., San Francisco, Calif.

The field experience with a water-in-oil emulsion in industrial hydraulic fluid applications has been very satisfactory. The primary function of fire resistance has been amply demonstrated. The knowledge obtained from commercial operations and laboratory experiments since the introduction of this type of fluid has been the basis for revisions in its formulation. These changes have resulted in improved performance. The viscosity of the emulsion at low shear rates has been reduced thus affording easier start-up of hydraulic equipment at low temperatures. Emulsion stability at both elevated and subnormal temperatures has been improved. Oxidation stability as measured by bench tests is equivalent to that of a high

C. E. Francis

R. T. Holmes

W. M. Schrey

quality steam turbine oil. The revised composition is more amenable to filtration through low porosity metal filters. Qualitative and quantitative measurements of wear of hydraulic pump components have been made both in laboratory and commercial hydraulic equipment. These have shown that significantly less wear occurs with the new formulation. As in the case of the initial emulsion, compatibility with the metals and seals usually present in hydraulic equipment has been maintained and odor and toxicity remain comparable to mineral oil.

Preprint No. 58AM 6C-1.

EVALUATION OF FLUIDS BY HYDRAULIC PUMP TESTS. W. M. Schrey, National Tube Div., U. S. Steel Corp., Pittsburgh, Pa.

Hydraulic oil is defined as an oil especially suited for use as a power transmission medium in hydraulically operated equipment. In the most complex of hydraulic systems this basic principle of power transfer can readily be seen. Since this transfer of power or pressure from one location to another is the purpose of hydraulic fluids, it would seem logical to assume the power transmittal qualities of a hydraulic fluid are of primary importance. However, contrary to logic, many of us frequently "put the cart before the horse" by spending innumerable hours in the laboratory determining various qualities of a fluid without a thought to the fundamental quality of power transmission.

Naturally the oxidation and corrosion resistance qualities of a hydraulic fluid are important, but if we wish to put first things first, we must initially answer the most important question "Will the fluid transmit pressure or power in a satisfactory manner?" Is it limited in any way in the transfer of power? For instance, is it satisfactory for a 1000 psi system but not adaptable in a 2000 psi system? Will it form varnish deposits, thereby affecting the transmittal of power through valves and controls? Laboratory wear tests will never measure the pressure capabilities of a fluid nor will laboratory bench tests foretell the effect of a fluid on valves and controls. Since hydraulic fluids are used to transmit pressure or power, it follows they should be tested by transmitting pressure or power . . . as in a hydraulic pump test. Pump tests are the logical answer to the testing of the fundamental qualities of a hydraulic fluid. *Preprint No. 58AM 6C-2.*

THE EFFECTS OF HYDRAULIC FLUIDS ON MECHANICAL PACKING MATERIALS. L. R. Tharp, E. F. Houghton & Co., Cleveland, Ohio.

Following general classification of fluids into three groups and packing materials into five groups, the combinations of hydraulic fluids and packing materials are discussed. Particular emphasis is given to effect of mineral oil aniline point on elastomers, with illustration of importance of choice of elastomer formulation suitable to aniline point range. General recommendations are made for selection of packing materials to be subjected to fluid types. *Preprint No. 58AM 6C-3.*

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EDITOR'S NOTE: A report of the reorganization of the ASLE Committee structure was published in **Lubrication Engineering** for May, 1956. With the formation of the new joint industry councils in April of 1957 and official recognition of the council structure for industries within the Society, the Organization and Operations Committee for the Society was charged with the responsibility for citing the relationship of the industry councils and technical committees to the overall Society structure. The following report shows the results of this definition.

Special Report: Reorganization of ASLE Committee Structure

January 21, 1958

GENERAL COMMITTEE STRUCTURE OF THE ASLE

Technical Committee Organization

Joint Technical Committee. General responsibility of the operation, policies and finances of the individual technical committees of the ASLE are vested in a joint technical committee (This supplants the general technical committee). This committee consists of a six-member executive committee together with the chairmen of the individual technical committees of the Society. The executive committee members are elected, two per year, by the Board of Directors to serve for three-year terms. The election is held at the Annual Meeting of the Board of Directors based on nominees secured for this committee by the Nominations Committee.

Retiring members of the Executive Committee of the JTC shall not be eligible for renomination to the same office for a period of one year following expiration of their term. The JTC shall be represented at meetings of the Board of Directors by its chairman, who shall be called the Technical Coordinator of the Society. The Vice President-at-Large shall, upon election to office, select from the membership of the Executive Committee of the JTC a vice-chairman, who shall automatically succeed to the post of Technical Coordinator at the close of the Annual Meeting the following year. The Technical Coordinator will report to the Vice President at Large and will attend meetings of the Board of Directors in an advisory capacity in order to report on the activities of the Technical Committees and recommend any desirable Board actions on the technical affairs of the Society. In case the Technical Coordinator is unable to attend any Board Meeting, he shall designate another member of the JTC Executive Committee to attend in his capacity. The Technical Coordinator shall be without vote in the proceedings of the JTC, except in the case of a tie vote. The duties of the JTC shall be prescribed in whatever detail is needed by acts or resolutions of the Board of Directors in keeping with the purposes previously outlined. Among these responsibilities shall be that of liaison with other technical societies. The JTC shall meet at least once annually at the time of the Annual Meeting and at such other times as it deems necessary. All members of the JTC including the Technical Coordinator, the Executive Committee members, and the individual technical committee chairmen shall be members of the Society.

Technical Committees. Technical Committees shall be agents of the Society in technical matters and under the general supervision of the JTC. The Technical Coordinator at the time he takes office shall secure suitable chairmen for the individual technical committees (subject to final approval and appointed by the President of the Society) and shall report the names of these committee chairmen to the Vice President at Large within one month following the Annual Meeting of the Society. Chairmanship of the technical committees shall be limited to a maximum term of three years, with two-year lapses necessary before reappointment of the same person to the chairmanship of the same committee. Each technical committee shall establish such sub-committees as it finds necessary drawing up membership of the committees and the Society at large. Sub-committees and functions of the technical committees shall include the following: *Research sub-committee*, for the development and execution of projects in the given field of a technical committee of direct benefit to the Society membership or to industry. *Papers and Publications sub-committee*, for the sponsorship of technical sessions on subjects in the committee's field and solicitation and sponsorship of papers on subjects in the committee's field for publication by the Society. *Information sub-committee*, for the development and publication through the Society of recommended procedures and practices in the committee's field and for answering requests for technical information received by the Society. *Abstracts sub-committee*, to furnish the abstracts of technical literature for publication by the Society.

Finances. Where a technical committee finds the need for financing certain of its projects and activities with Society's funds, the following procedure shall be followed: The technical committee shall submit a detailed statement of its need for such funds to the JTC at the time of the Annual Meeting. From these statements received from the technical committees, the JTC shall prepare a proposed annual budget for the coming year and submit it to the Vice President-at-Large and the Finance Committee no later than September 1 of each year.

Industry Council Organization.

Joint Industry Council (JIC). The responsibilities for the operation, policies and finances of the individual industry councils of the Society shall be invested in the JIC. This Joint Industry Council shall consist of the chairmen of the individual industry councils plus a chairman and vice-

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A rebuilt diesel cylinder head is sprayed with 'dag' 154 as assembly lubricant at United Welding Processes, Inc.

Pre-assembly application of 'dag' 213 prevents piston seizure at Walter Kidde & Co.

Walter Kidde & Company manufactures a four-stage aircraft compressor, the heart of an airplane's pneumatic system. Absolute operational reliability must be guaranteed. Lives depend on it. Therefore, particular care is taken during run-in to insure the compressor's operation against the possibility of piston seizure. By applying 'dag' Dispersion No. 213 — colloidal graphite in an epoxy-resin solution — to the aluminum pistons before assembly, Kidde has solved this problem. The piston coating is applied by spray, then oven cured at 350° F. for 2½ to 3 hours. The result is a film which is hard, durable, and inherently slippery. During run-in the graphite works into the surface to become practically integral with the metal. The application of 'dag' colloidal graphite, together with their ultrasonic cleaning technique which prepares a cleaner surface beforehand, completely eliminates galling and seizure thus cutting rejects during break-in to 2%. Acheson dry film lubricants provide the answer to many such pre-assembly applications; surface protection against oxidation, aiding press-fits of cylinder liners into engine blocks, etc. Bulletin 435 on dry film lubrication and reprint MW, containing further information is available at your request. Or call in your Acheson Service Engineer.

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Committee Reorganization

(Cont. from p. 180)

chairman, who may also be chairmen of individual councils. The JIC shall be represented at meetings of the Board of Directors by its chairman who shall be called the Industry Coordinator of the Society. The Vice President-at-Large shall, upon election to office, select from the past or present chairmen of the individual industry councils, a vice-chairman for the JIC, who shall automatically succeed to the post of Industry Coordinator at the close of the Annual Meeting the following year. The Industry Coordinator shall report to the Vice President-at-Large and shall attend meetings of the Board of Directors in an advisory capacity to report on the activities of the industry councils and recommend any desirable Board action on the industry relations of the Society. In case the Industry Coordinator is unable to attend any Board Meeting, he shall designate another member of the JIC to attend in his capacity. The Industry Coordinator shall be without vote in the proceedings of the JIC except in the case of a tie vote. Duties of the Joint Industry Council shall be prescribed in whatever detail as needed by acts or resolutions of the Board of Directors in keeping with the foregoing purposes. The Joint Industry Council shall meet at least once annually at the time of the Annual Meeting and at such other times as it deems necessary. All members of the Joint Industry Council, including the Industry Coordinator, the Vice-chairman and the individual council chairman shall be members of the Society.

Industry Councils. Industry Councils shall be the agents of the Society in programs, projects and activities designated to improve industrial lubrication. Councils shall operate under the general supervision of the Joint Industry Council. It shall be the responsibility of the Industry Coordinator at the time he takes office to see that the individual councils have suitable chairmen (subject to the final approval and appointment by the President of the Society) and to report the names of these chairmen to the Vice President-at-Large within one month following the Annual Meeting of the Society.

Industry Councils may develop their own organizational structure, their own scope of activities, and their own rules for governing these activities, provided such structure, activities and rules are contained in the Council's By-Laws approved by the JIC and the Board of Directors. Where other approved By-Laws have not been established for industry council operation, the general rules set forth under Technical Committee operations shall be followed.

Finances. Where an industry council finds the need for financing of its projects and activities with Society's funds, requests for these funds for the coming year shall first be received by the JIC prior to submission to the Board at its Fall Meeting. The Industry Councils shall not obligate themselves to the Society for any funds without specific approval of the Board of Directors.

Other Committees of the Society.

Directors' Sponsorship of Committees. The Society's committees shall be organized under eight main classifications with each director of the Society being responsible as director-sponsor for one of these classes. Assignment of each director's class of committee responsibility shall be made by the President at the first meeting of the new Board of Directors. A director-sponsor shall be a member ex-officio of each of the committees in the class assigned and shall see that each committee functions and carries out its prescribed duties during his term of office. He shall pass on to the successor director-sponsor his complete files covering these committee responsibilities. The recommended classes of committees are as follows:

Program Committee: Program, Lubrication Conference.
Professional Development Committee: Awards, Education.
Publications Committees: Editorial, Abstracts.
Meetings Committees: Annual Meetings, Exhibit Arrangements.
Membership Committees: Memberships and Admissions, New Sections, Industrial Membership.
Projects Committees: Projects, Handbook Advisory.
Rules Committees: By-Laws.
Operations Committees: Nominations, Finance, Organization and Operations.

Director-sponsors shall secure suitable chairmen for each committee for which he is responsible, (subject to final approval and appointment by the President of the Society) with the exception of the Nominations, Finance and Editorial Committees as provided for in the By-Laws. The names of these committee chairmen shall be reported to the President no later than the Annual Meeting of the Society. It shall be the duty of the director-sponsor to instruct his new committee chairmen in the mechanism of liaison with the Board of Directors.

Chairmanship of Committees. Chairmanship of a Society committee (With the exception of the Finance and Editorial Committees) shall be limited to a maximum term of three years, with a one-year lapse necessary before reappointment of the same person to the chairmanship of the same committee.

Finances. Where a committee finds need for financing projects or activities with Society's funds, the following procedure shall apply.

The committee shall submit a detailed statement of its need for such funds to its Director Sponsor at the time of the Annual Meeting. With these statements received from these committees the Director-Sponsor shall prepare a proposed annual budget for his class of committees and submit it to the Finance Committee no later than September 1 of each year.

Promotion of Committee Service by Society Members.

The President-elect with the assistance of the Administrative Secretary and the officers and directors of the Society and the individual committee chairmen shall promote membership on Society committees. The following procedure is recommended:

Annually, not less than 30 days before the Annual Meeting, the Administrative Secretary shall transmit to all voting members of the Society an invitation to participate in Society committees. From the returned invitations, a list of names and addresses will be prepared. These names would be submitted to the corresponding director-sponsor by the incoming president at the time of the Annual Meeting for use by the committee chairman. Sponsors should instruct their committee chairmen to use all possible volunteers and acknowledge all such requests.

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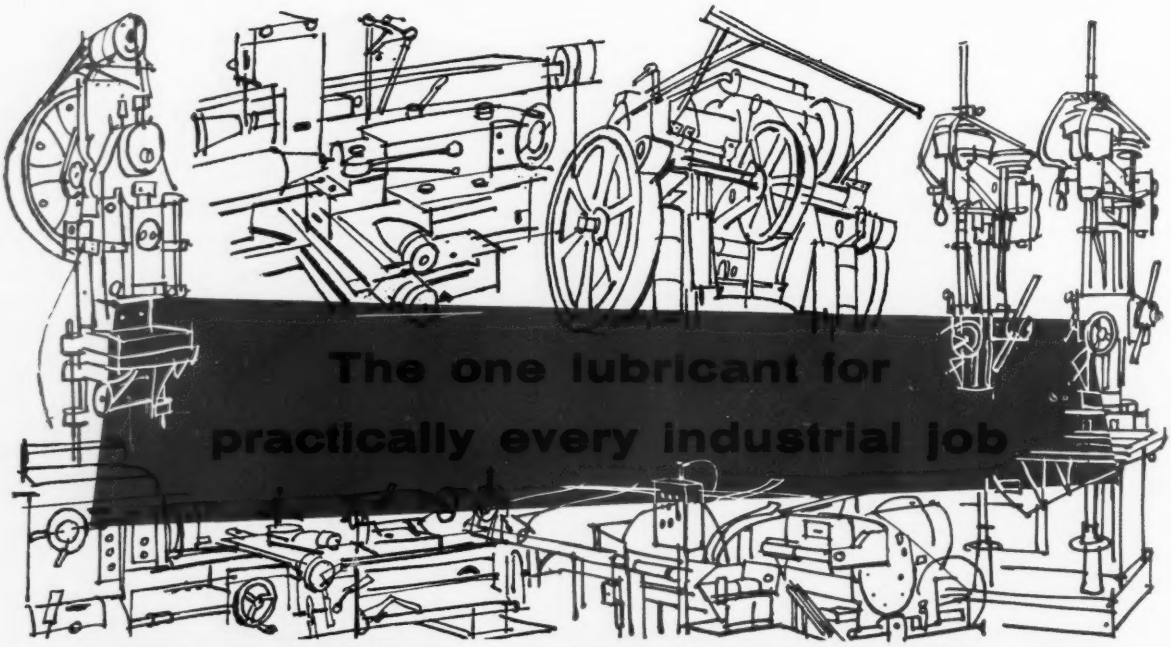

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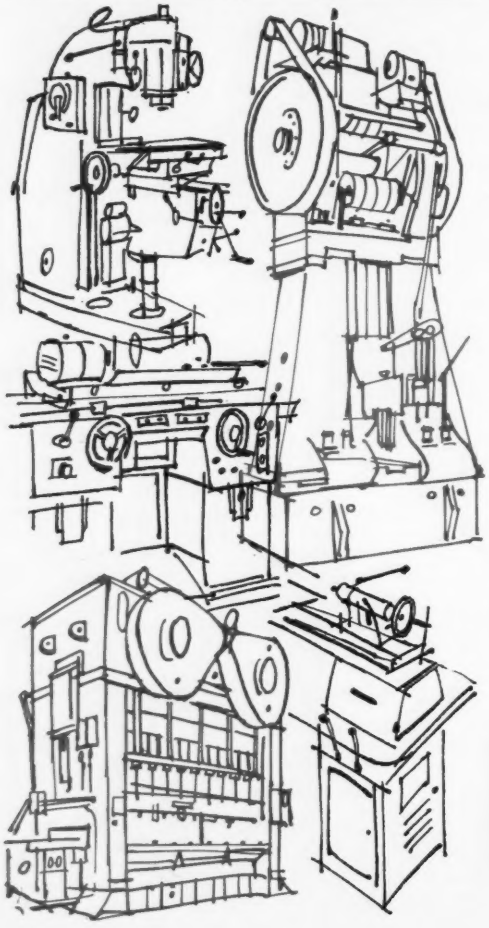

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Book Review

"Nuclear Chemical Engineering" by M. Benedict and T. H. Pigford, Published by McGraw-Hill, N.Y.C., 1957, 594 pages, $9.50.

Reviewed by C. H. Barkelew, Shell Development Co.

"Nuclear Chemical Engineering" is one of a series of books planned by McGraw-Hill on the general subject of nuclear engineering. It covers the parts of chemical engineering which are involved in the processing of fuels for fission reactors. The text has evolved from notes used in course work at the Massachusetts Institute of Technology. The contents include three chapters on physical background material; five chapters on chemical processing of reactor materials including uranium, zirconium, beryllium, thorium and used fuel elements; four chapters on isotope separation with particular attention given to deuterium and uranium, and an appendix with 50 pages of data tables. Each chapter except the first has a bibliography and a set of illustrative problems.

In the reviewer's opinion, this book would more appropriately be titled "Nuclear Chemical Processing," since many of the subjects generally considered as being within the scope of chemical engineering are not discussed. Conspicuous omissions include heat transfer and fluid mechanics, both of which are exceedingly important in power reactor engineering. There is no mention of the special chemical engineering problems involved in the operation of homogeneous reactors.

Within its scope, this book is an excellent text, and can be recommended without qualification to anyone who wants to learn about the subject. Intended primarily for students, it can be read profitably by the practicing engineer, particularly if he works all the problems. These are well chosen and adequately cover the subjects discussed in the text.

In any field which is rapidly developing, processes, techniques, and textbooks become obsolete quickly. This book covers its subject up to and including the Geneva Conference, whose proceeding were published in 1956. The reader must remember that familiarity with this book will not guarantee a knowledge of the latest developments in the field. He must keep himself up to date by reading new material as it appears, continually referring to the textbooks for thorough discussions of underlying principles. For this purpose, "Nuclear Chemical Engineering" is one of the best books published on the subject to date.

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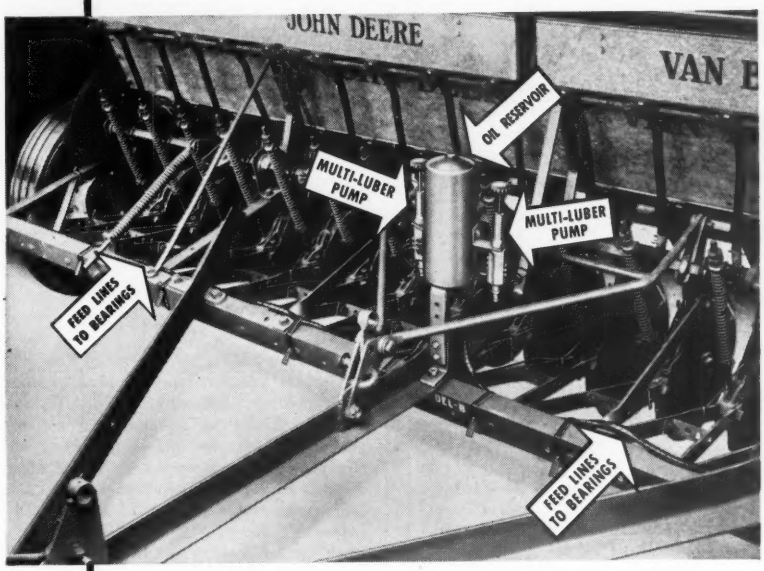

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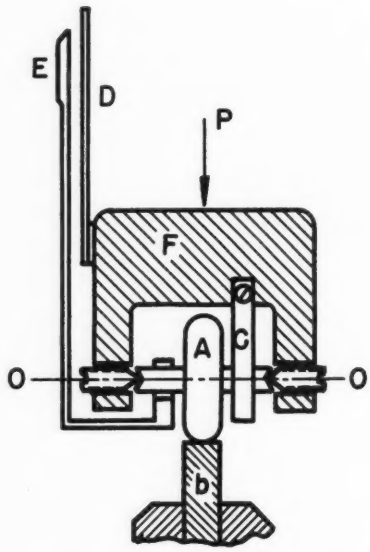
Summeries of Foreign Papers

Prepared by the ASLE Lubrication Fundamentals Committee

"New Method of Determination of Coefficient of Sliding Friction and Its Application to the Study of Adsorptional Lubrication." G. I. Epifanov, F. P. Soloshko, and P. A. Rebinder. *Doklady Akademii Nauk SSSR*, v. 99, no. 5, 1954, 801-4.

The object of the friction testing device developed by the authors has been the elimination of the "self-excited relaxational vibrations" of the conventional kinetic coefficient of friction machines. This discontinuous variation of the fractional force is attributed to variable periods of "motionless contact". Thus in normal friction-measuring devices consisting of spring-type dynamometers for holding a slider in a stationary position, it is claimed that the self-excited relaxational vibrations produce the apparent discontinuities in friction values. While the authors have not developed the various phases of the stick-slip theory, they state that it is not clear whether these variations are real or not, i.e., whether the frictional force is really inconstant, or whether these changes are the result of peculiarities in the system for measuring the forces.

The friction testing apparatus, shown in the schematic diagram, is designed for two rotating cylinders, the surfaces of which are the materials under test. The upper cylinder (A), which may be replaced by a spherical surface when spot contact is desired, is mounted on a shaft supported in a yoke (F). The shaft of A is free to rotate around the axis (O-O); a pointer (E) mounted on the shaft indicates the frictional force on dial (D). The lower cylinder (b) is rotated at constant speed and pressure against the surface A. The shaft of cylinder (A) is attached to the inner end of a helical spring, and the outer end of the spring (C) is screwed to the yoke. In starting, the apparatus (A) turns in contact with the specimen cylinder (b)



Schematic Diagram of friction tester.

under pure rolling friction, the spring becoming wound up as the rolling occurs. There is then a transition to a condition of partial rolling and sliding friction. Finally as the test proceeds rolling friction decreases and only sliding friction prevails. According to the authors, in this method, in which there is an asymptotic approach to the state of pure sliding friction, any excitation of relaxational vibrations in the system is prevented. The force indicated by the displacement of the helical spring under equilibrium operating conditions, shows only the force of sliding friction. The results of preliminary experiments with a tempered high speed steel spherical rotor (A) and an annealed pure iron cylinder (b), are of the order shown in the accompanying table.

Surface Active Additive in C_6H_6	Additive Concentration, Millimols	Coefficient of Friction
Methyl Alcohol	40	0.60
	120	0.45
Octyl Alcohol	40	0.45
	120	0.33
Cetyl Alcohol	40	0.34
	120	0.23
Stearic Acid	40	0.12
	120	0.12
Sodium Oleate	40	0.13
	120	0.15

(Continued from p. 186)

At higher additive concentrations (500 to 26,000 millimols) the depression in friction is of the same order for the three alcohols tested. The molar concentrations at which there was the greatest effect on friction depression decrease with increase in the length of the hydrocarbon chains (Duclaux—Traube rule for surface activity). For sodium oleate the minimum friction was at a concentration of about 10 millimols, which may be due to a chemically-bound monomolecular layer of oleic acid. *(Summarized: E. N. Klemgard)*

"The Chemist Faces Lubrication Problems." G. Hugel. *Rivista dei Combustibili*, v. 9, no. 5, 1955, 417-34.

Experiments are carried out on a Faville tester to study the relationship between structure and activity of sulfur and chlorine-containing extreme-pressure agents. The best sulfur compounds were benzylic or allylic sulfur compounds. It is found that:

1. The amount of iron sulfide on the sliding surfaces increases with increasing pressure in the presence of active agents.
2. Iron sulfide disappears prior to seizure when ineffective agents are employed.

It is difficult to explain why active compounds cause seizure at the instant of maximum iron sulfide on the surface. Mixtures of sulfur and chlorine additives are studied to see if an explanation can be found. The chlorine additive used is pentachloro-t-butyl benzene which contains nonreactive chlorine. Test results indicate that mixtures of these two types of additives give better results than either alone. It is also shown that the addition of a chlorine additive in the presence of sulfur lowers the content of iron sulfide on the sliding surface. This indicates that pellicles of iron sulfide are formed on the surface and constantly removed and reformed. Probably the action of chlorine additives is to deterge iron sulfide from the surface. These particles coming from the surface and subsequently suspended in the oil do the lubrication. A number of solid lubricants other than iron sulfide suspended in oil are studied. The nature of the solid and the dispersion are found to play important roles. It is then concluded that the removal of iron sulfide from the sliding surface is a factor in lubrication. In the absence of dispersing action, iron sulfide on the surface is compressed under very high pressure until it becomes incorporated into the surface and no longer lubricates, resulting in an increase in friction and seizure of the specimens.

Some iron shafts are sulfurized and tested in plain mineral oil. The performance is compared to that obtained with regular shafts tested by immersing in oil with sulfur additives. The observed difference in performance is attributed to the structure of iron sulfide. This study revealed that the crystalline form of the iron sulfide is another factor influencing its effectiveness in lubrication.

Microscopic examination of the sliding surfaces reveals more information. Sulfur additives show a number of streaks on the shaft which are parallel to the shaft and to the direction of rotation. Chlorine additives allow much greater pressure but give more wear (metal chips observed). Sulfur and chlorine together give a regular granular surface. Sulfur is adjusted to 2% and chlorine to 3-4% of the total weight for best wear.

The addition of 2% of *bis* trichlorobenzylxanthate glycol (a multifunctional additive) gives practically the same results as the mixtures.

The following conclusions are drawn from a study of photographs of these phenomena:

1. In lubrication, extreme-pressure particles are always torn from the surface.
2. These particles come from the metal or material from the reaction of metal and additive.
3. Particles are removed by the washing with oil, in particular by high oxygen-containing oils (diesters etc.).
4. If viscous oils are used, the particles are not washed out and give streaks on the shaft in all directions.
5. At about 1500 kg. load all shaft streaks are parallel, therefore all of the oil has been removed by the pressure.

The two main conclusions are:

1. A chemical reaction takes place between the surface and the active agent. This reaction facilitates the formation of very small wear particles.
2. Lubrication phenomena are principally of a microscopic order of magnitude. *(Summarized: G. C. Knapp)*

"Influence of Surface-Active Agents on the Dimensions of Chip Elements in Cutting." G. I. Epifanov. *Doklady Akademii Nauk SSSR*, v. 104, no. 1, 1955, 68-71.

The relation is studied of cutting forces in planing operations to length of slip elements (the cutting distance in mm. over which one slip element of a chip is formed). Force-distance diagrams of single iron chips obtained dry, with methyl alcohol with ethyl laurate, and with carbon tetrachloride as cutting fluids are shown in Fig. 1. Without lubrication the number of serrations or slip elements per unit of chip length is relatively small. With lubricants such as ethyl laurate and CCl_4 the number of slip elements is greatly increased (smaller in size) and the cutting forces are much less.

Typical results are shown in Table 1. The most active fluids result in chips having slip elements that are about one tenth the lengths measured for elements made without lubrication. A theory of cutting action is proposed. The active cutting fluids increase the rate of strain-hardening and metal toughness is decreased. The metal in the rupture zone is converted to a "limiting state," where there is reduced work of chip deformation and surface friction is localized. A possible explanation of these cutting lubricant effects is that the active agents may be introduced into the space lattice of the metal crystals being machined. In the cutting zone there may be catalytic decomposition of the surface active molecules. Chemical activity of the decomposition products may result in additional distortion and metal embrittlement, tending to decrease the slip element dimensions.

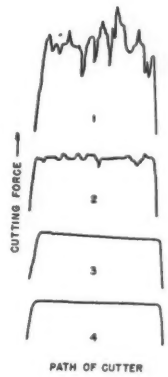


Figure 1. Graphs recording cutter force vs. path of cutter during cutting of iron chips; (1) dry, (2) with methyl alcohol, (3) ethyl laurate, and (4) carbon tetrachloride.

TABLE I

CUTTING DISTANCE PER SLIP ELEMENT (mm. over which one slip element of chip is formed).

METAL	DURAL	IRON	COPPER
Cutting Speed, mm/min.	3	10 (cm/min)	10 (cm/min)
Cutting Tool Angle, degree	78	68	58
Depth of Cut, mm.	1.0	0.15	0.20
Cutting Distance/Slip Element, mm.			
Dry	12	6	0.17
Menthyl Alcohol	4.0	1.2	0.09
Oleic Acid	3.0	—	—
Ethyl Laurate	2.0	0.5	0.05
CCl_4	—	0.17	0.04

(Summarized: E. N. Klemgard)

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ASLE News Notebook

Compiled by
R. D. McCormick

Executive Reports

Minutes of the Executive Committee meeting held January 20th, were received by the Board. Highlights of the Executive Committee meeting report include the following items: The Organization and Operations Committee was instructed to give study and consideration to voting privileges of regional vice presidents and prepare a report covering this matter. Financial statement for the period ended December 31, 1957 was received.

The National Office was instructed to prepare copies of preprints of each paper to be presented at the Annual Meeting to be made available on a mail order basis *only* after the Annual Meeting to those who order copies of the papers.

The proposed 1958 Budget was accepted as revised.

A report covering office facilities and future requirements for the National Headquarters was received and the Executive Committee recommended continuation of the study.

Through Committee action, the affiliation with ASA was severed.

The Committee received a report from the Administrative Secretary covering advertising in the Journal and submitted the following recommendations to the Board of Directors: 1. That the Administrative Secretary be authorized to engage publishers representatives to handle the sale of advertising space for *Lubricating Engineering* in the central area of the United States. 2. That sufficient money for this purpose be appropriated in the advertising budget during 1958. 3. That such contract between the Society and the advertising space representative become effective February 1st, 1958.

Board Actions

The minutes of the October 8, 1957 Board of Directors Meeting were approved as corrected. (58-1) The report of the Treasurer was read as received (58-2). The 1858 budget as modified by the Executive Committee was approved (58-3). Reports of the Administrative Secretary and recommendations contained therein were approved (58-4). The National Office was instructed to advise Annual Meeting authors that preprints would not be distributed by ASLE at the 1958 Annual Meeting and that authors desiring to make preprints of their papers available to registrants at the meeting be invited to supply 250 copies for this purpose, plus an additional 100 copies to the National Office for subsequent distribution on a mail order basis. The National Office was instructed to prepare cover sheets for those authors agreeing to provide preprints at the meeting (58-6). Registration fees for the 1958 Annual Meeting were fixed by Board action at $7.00 for members of the Society and $10.00 for non-members (58-7).

In a special report from the Organization and Operation Committee, a formal document defining the structure of the Society and the Joint Industry Councils was approved and accepted by the Board (58-8). Reports of the Joint Technical Committee Coordinator were read covering plans for a gear and gear lubrication committee-sponsored symposium to be held during the first quarter of 1959. By Board action the Committee was encouraged to complete plans for a symposium to be held in 1959, January 26 and 27, at the Morrison Hotel, Chicago, Illinois (58-9, 10). The Board suggested that the AGMA, SAE and ASME be invited to participate in the proposed gear symposium (58-11).

JOINT INDUSTRY COUNCIL COORDINATOR

No report.

EASTERN REGION

A comprehensive report on each of the sections comprising the Eastern Region was given by Eastern Regional Vice President, M. E. Dougherty. Of the 11 sections reporting, all report active membership work, eight report planned educational activities, one reports no course scheduled for 1958 and two sections have no reports. Slight membership increases were shown by all except one section.

CENTRAL REGION

No report.

MIDWESTERN REGION

Two hundred and seven members were predicted for the Midwestern Region, based upon two new sections supplying 50 members plus 157 new ASLE members from the nine existing sections.

Final plans were described for the Chicago Section sponsored Joint Automotive Lubrication Conference held with the Chicago Section of the SAE, March 11, 1958 (See article elsewhere this issue): Six technical papers, three each sponsored by the two sponsoring sections, social hour and dinner with a speaker.

WESTERN REGION

Four existing sections in the Western Region have reported, with two California Sections showing membership plans in effect and steady growth. Both have continuing education programs and are well organized for the 1958-59 period. The two newer sections in the Western Region centering about Salt Lake City, Utah and Seattle, Washington are well organized, though growing more slowly. Their growth can be related to the density of industry in the two areas, and future strength will be dependent upon aggressive leadership.

CANADIAN REGION

No report. The proposed trade name listing of products related to the field of lubrication and lubrication engineering was dropped by

Board action (58-13). A recommendation concerning the changes in titles for the Editorial Staff was approved (58-14). Resolution presented by the Publications Committee is as follows: Be it resolved that in the future before Board authorization is granted for publication of preprints, pamphlets and other publishable material that such a proposal be referred to the Publications Committee for publication recommendations. It was approved (58-15).

Committee Reports

BY-LAWS

The By-Laws Committee requests a fund allocation in the 1958 budget for the review, editing and printing of by-laws as revised by the Committee. Estimated cost — $750.00. Preliminary drafts of the by-laws were anticipated for the 1958 Annual Meeting.

JOINT LUBRICATION CONFERENCE COMMITTEE

October 13 through 15 have been set as dates for the 1958 Joint Lubrication Conference with the American Society of Mechanical Engineers at the Hotel Statler in Los Angeles. Conference arrangements are proceeding satisfactorily and the survey questionnaire sent to registrants of the 1957 conference in Toronto indicates many people from the East plan to attend the Los Angeles meeting. The number of wives anticipated for this meeting indicates the desirability of planning for a wives' program. Many people responding to the conference questionnaire suggested a special program for the wives.

TELLERS

A Tellers Committee has been formed and will report upon the 1958-59 slate of nominees at the April Meeting.

NOMINATIONS

The nominations Committee completed its assignment and supplied information for the preparation of ballots for the 1958-59 elections.

FINANCE

The Finance Committee, in submitting the 1958 Budget to the Officers and Directors for approval, has indicated that though this budget is not as satisfactory as the Finance Committee would prefer it to be, it is the most realistic the committee is able to present.

AWARDS

Nominations for the four awards presented by the ASLE were presented to the Board and approved. A full report on nominee recipients will be made in the following issue of *Lubrication Engineering*.

EDUCATION

Education course sponsored by the Society held in conjunction with the 1958 Annual Meeting is scheduling five sessions. These sessions were defined in the program accompanying the March issue of *Lubrication Engineering*.

MEMBERSHIP AND ADMISSIONS

For the first time in the Society's history, membership exceeded 3,000 members when, as of December 31, 1957, membership reached 3,047, an increase of 219 members from April 30, 1957.

A competitive membership program among the sections of the Society has been instigated by the Membership Chairman. The program is based on dividing sections into three groups, those with less than 50, those with 50 to 100 members, and those with more than 100 members. A competitive membership program of this type may encourage greater individual section membership activity.

NEW SECTIONS

A new section with headquarters in Dallas and Fort Worth has been formed since the last Board meeting. Organizational meetings were held in the Davenport-Rock Island area with approximately 15 persons attending. With these potential members plus the 11 members currently residing in that area, a new section is anticipated.

INDUSTRIAL MEMBERSHIP

A proposal covering the rebate of fees collected from industrial membership to the sections is being considered and will be proposed to the Board for evaluation at the April 1958 Meeting.

TRADE NAME LISTS

This proposed project has been dropped.

JOURNAL BEARING RESEARCH

A completed project has been reported previously, and the book is now available from the National office.

EDITORIAL

Plans for the publication of 25 papers available from previous national meetings and other sources have previously been reported. The committee forecasts the availability of 40 papers suitable for publication from the Annual Meeting, 15 papers from the fall conference and 15 papers from other sources. Publication of these papers shall be split between *Lubrication Engineering* and the new ASLE *Transactions*. Under the reorganized structure in working with the Annual Meeting Program Committee, it is anticipated that Annual Meeting papers can be reviewed and authors notified within a month after the meeting as to publication status. Publishing commitments for the entire year can be made available to the National Office within two months after the Annual Meeting.

ABSTRACTS

A total of 68 abstracts has been published since January 1957 and, with the appointment of an Abstracts Sub-Committee chairman for the Hydraulics Committee, only one committee has not appointed a sub-committee chairman for abstracts. The abstract operation appears to be functioning smoothly.

PROGRAM

Program status as of January 6 was as follows: 18 sessions scheduled, 11 sessions completed, 5 sessions requiring one paper for completion, 2 sessions in doubt, 52 Offers of Paper forms received, 12 papers tentative.

PUBLICATIONS

The most serious problem facing the Society has been ways and means of reducing the backlog of unpublished papers while keeping pace with the influx of new papers from Annual Meetings, fall conferences and other publication sources. Recent conclusion of publishing arrangements with Pergamon Press to publish the new ASLE *Transactions* should solve a number of the publishing problems, and issues of the first volume for 1958 are anticipated for distribution at about the time of the 1958 Annual Meeting, the second issue to be distributed in fall of 1958.

The first issue of the ASLE *Transactions* will contain 27 papers including 10 of the 12 papers sponsored by the ASLE at the 1957 Fall Conference. The remaining two papers from the 1957 Fall Conference will be published in the second issue. In view of the critical cost nature of all publication operations undertaken by the Society, the Publications Committee offered a resolution to be adopted by the Board (See Board Actions).

ANNUAL MEETING

The Cleveland Convention Committee and chairmen of the respective sub-committees have completed their plans.

Design and Testing Considerations of Lubricants

(Cont. from p. 152)

definitely causing wear. In Step 2, the slope indicates that there was little, if any, wear. These two curves in Figure 9 seem to indicate that starting and stopping are wear promoters. If the machinery can be started under light loads, thus allowing an oil film to be developed before a heavy load is applied, then this initial wear can be reduced.

The information plotted in Figure 10 is the result of a similar set of test gears, but run with a different type of gear oil. From a scoring point of view, this new oil had about the same ability to withstand scoring as some of the other oils, that is, they calculated approximately the same "Temperature Flash" constant. This oil had different wear characteristics as indicated by the curve. Initially, the pinion started to wear at a very high rate, then the rate of wear dropped off and the test settled down to a rather see-saw, erratic wear pattern for the remainder of the test. Undoubtedly, the peaks and valleys are due to small and large particles moving by the counter at different intervals. It is quite definite, however, that this oil had inferior wear characteristics and, although it checked out all right from a scoring point of view, it would be unsuitable for high speed equipment where long life is a requirement.

It is the author's understanding that many anti-scoring additives are actually wear promoters. This being the case, then the radioactive technique of gear testing can be a useful tool in determining their wear characteristics. In some applications, an additive of this nature may be quite harmful, as in a high speed jet engine. In other applications, they may be completely acceptable; for example, a rocket or torpedo mechanism.

CONCLUSIONS

Since scoring and long range wear are the two main types of gear failures commonly associated with the lubricant, then they are the problems to be solved by the industry. The Kelley equation backed up with gear test results, is a guide and a method for studying the scoring problem. The radioactive technique of gear testing offers a workable procedure to study the wear phenomenon. These two tools at present hold the most promise for breaking down the lubrication barrier and permitting gear designers to take full advantage of the manufacturing techniques, heat treating know-how and the capacity of the gear material that they have at their command.

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Design and Operation of Ball Bearings

(Cont. from p. 158)

The author is also indebted to the U. S. Atomic Energy Commission and Westinghouse Electric Corporation for permission to publish this work.

GLOSSARY OF TERMS

1. RADIAL PLAY (Radial Internal Clearance or Diametral Clearance) — The total diametral movement of one bearing race with respect to the other when a specified radial load is reversed. One race is usually clamped.
2. AXIAL PLAY (Also called End Play) — The total movement observed when the direction of a standard axial load is reversed. One bearing ring is clamped in a fixed position; the other moves as the load is reversed.
3. CONFORMITY — A term used to define the radius of curvature of the ball groove in relation to the ball diameter and is usually spoken of in terms of percentage of ball diameter. Thus, a 52% conformity defines the groove radius as 52% of the ball diameter.
4. CONTACT ANGLE — The angle between a line through the ball-race contact points and a line or plane through the ball centers and perpendicular to the axis of rotation.
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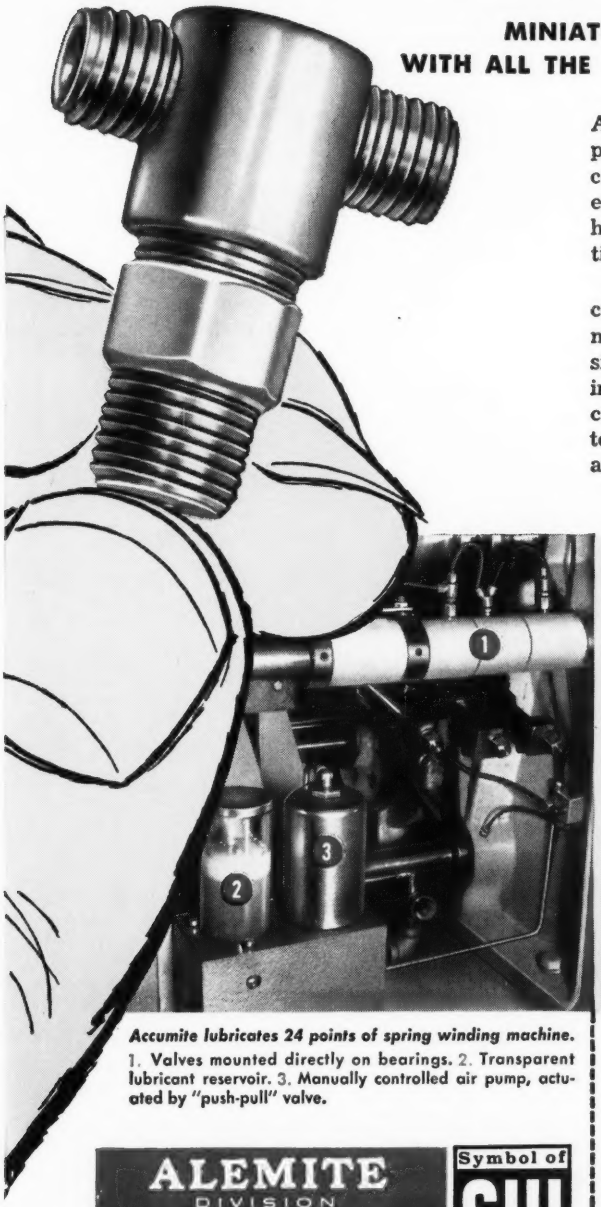

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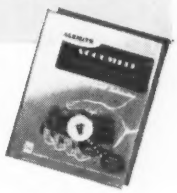

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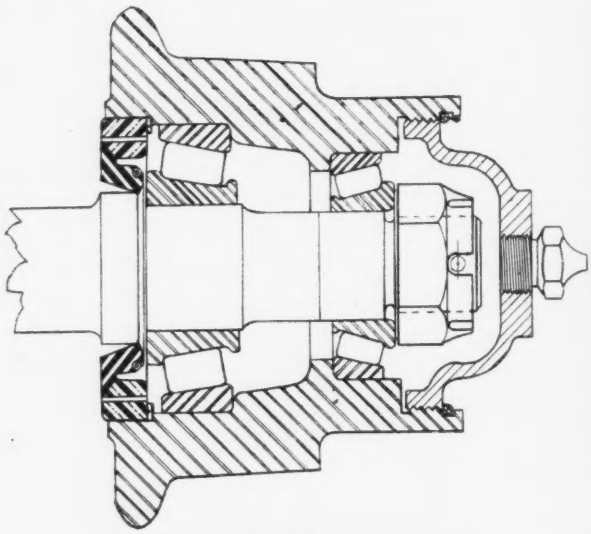

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